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A CURRICULUM ACTIVITIES GUIDE TO WATER POLLUTION AND ENVIRONMENTAL STUDIES. ACTIVITIES. VOLUME I.

Environmental Protection Agency
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A CURRICULUM ACTIVITIES GUIDE TO

WATER POLLUTION AND ENVIRONMENTAL STUDIES

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

ACTIVITES

VOLUME 1

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A CURRICULUM ACTIVITIES GUIDE
TO
WATER POLLUTION
and
ENVIRONMENTAL STUDIES:
ACTIVITIES - VoL-1

U. S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF WATER PROGRAMS
MANPOWER DEVELOPMENT STAFF
TRAINING GRANTS BRANCH
1972

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Preface

There is great desire on the part of students today to be directly involved in their society and its problems. This guide is designed to bring students and their educational process into direct contact with their society and their community. This requires that learning occur in all areas of the society, not just those special places called classrooms. As one student remarked, "You actually learn by going out and doing what you are learning in theory, which is something I never did before." Stepping outside the classroom or expanding the classroom to encompass the life space of the student is an important aspect of this program. For it is only there and then that the theory of disjointed, "irrelevant" facts begin to assume meaning. For this reason, the guide is primarily activity-oriented.

The activities contained in this guide utilize a process of inquiry which will lead the student to acquire knowledge and skills needed to understand and solve the problems of his environment. The activities are designed to arouse his interest and curiosity through direct observation and investigation. Since there is no planned sequence or order, each user of the guide (student or teacher) will develop his own path of inquiry. The activities themselves are only meant as a starting point, a guide; it is expected that in practice the users will expand upon them both in depth and breadth.

Volumes I and II are concerned with only one aspect of the environmental problem, water pollution. However, the investigation of water pollution itself is not limited to a specific academic field of inquiry. If water pollution or any of our environmental problems are to be solved they must be understood in all their manifestations. This means that any study of the problems must be interdisciplinary in nature and must take into account the social and political aspects as well.

The students and teachers who developed this program encountered numerous frustrations and achieved many successes. There were burned fingers and cut feet, leaky hip boots, shivering bodies and colds, philosophic "differences," midnight arguments, and some pretty firm convictions. Pervading all this, however, was the shared knowledge that something was happening. People were involved - students and teachers together, developing relationships which created changes in attitude. And those attitudes caused changes in behavior which have persisted beyond expectation.

Since the initial work in the summer of 1969, teachers and students have traveled hundreds of miles to lead training conferences, workshops, and at least nine more major training programs. They have testified in Congress, conducted research work, taught classes, and formed a national teacher-training and curriculum development organization, The Institute for Environmental Education, headquartered in Cleveland, Ohio. The sequel

The four areas dealt with in volume I are the hydrologic cycle, human activities, ecological perspectives, and social and political factors.

publications to these volumes, on the construction of equipment described in Volume II, land studies, consumerism, community health, transportation, a hand guide on introducing environmental studies into the school and other community organizations, etc., are in preparation now. These are all results of teachers and students studying and working together on environmental community problems.

Joseph H. Chadbourne, President
Institute for Environmental Education

Acknowledgments

There were many people who contributed to the completion of this guide. Special thanks go to Joseph Chadbourne, President of the Institute for Environmental Education, who conceived the original idea and secured the backing of the Ford Foundation and of the Department of the Interior, and to Alan McGowan, Scientific Administrator, Center for the Biology of Natural Systems, Washington University, St. Louis, Mo., who directed the workshops funded by these grants during the summers of 1969 and 1970.

We are grateful to Robert Snider, Director of Training Grants, Office of Water Quality, Environmental Protection Agency, who identified and encouraged the germination of this work at the University School, Cleveland, O., in 1967. We also express our warm appreciation to Bernard Lukco, Environmental Protection Agency, who continued the direction given by Mr. Snider and tirelessly aided the directors throughout the 2-year effort. We are also indebted to Dr. Herbert W. Jackson, Chief Biologist, and F. J. Ludzack, Chemist, both of the Taft Center in Cincinnati, O., who provided checks on the technical accuracy of the aquatic biology, chemistry and bacteriology sections of the guide. E. Girtsavage and D. Smith from the New England Basins Office of the Department of the Interior made available to us a great deal of information from their training program.

Many thanks are due to the Millipore Co., Bedford, Mass., and to the LaMotte Chemical Co., Chestertown, Md., for their generosity in supplying equipment to the workshops, films, and technical advice on many occasions.

This guide was organized and edited by the team of John Hershey, Stephen McLoy, Albert Powers, and Alan Sexton. They remained long into the summer months of 1970 to compile the contributions of numberous writers: Philip Murphy, Robert Touchette, and William Schlesinger for the chapter on Hydrologic Cycle; Raymond Whitehouse on Human Activities; Alan Sexton and Robert Graham on Ecological Perspectives; John Hershey for Social and Political Factors; and Albert Powers, Alan Sexton, Philip Murphy, Richard Fabian, and Rodney Page for Appendix 1. These men assembled the written experiences of the 1969 and 1970 participants; they then rewrote and produced this guide. Those weeks were tolerable only because of Susan Bayley's secretarial assistance and light heart.

Preparation and correction of the camera copy was done by Kay Bela, Training Grants Branch, Environmental Protection Agency.

A final note of gratitude is extended to the members of the many schools who are now using the activities and sending suggestions, corrections and new activities to the Institute for Environmental Education.

Good luck and have fun.

John T. Hershey
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INTRODUCTION

In 1967, a small band of teachers and students began studying one community's water problems and serving one public pollution agency. Now there are large bands of teachers and students, located in many communities, studying many environmental problems and serving many public agencies. Over those years, a philosophy developed and some of the studies were written into Volumes I and II of this guide. This Introduction contains the essentials of that philosophy and a brief "tour" through the two volumes.

The philosophy is that students, teachers, and community members can work together as co-learners as they investigate real problems of the real world. This necessitates a re-examination of many traditions -- teacher role, textbook, classroom, student responsibility, Carnegie Unit, the school day, the learning process, curriculum, etc. -- and a subsequent development of more effective educational processes.

The following are the elements of our philosophy as they relate to students, teachers and the educational institutions:

1. Students possess the ability to determine, in cooperation with each other and with teachers, their educational program and the particular means they will utilize in problem investigation. An outgrowth of this process will be continuing self-learning.

2. As the students progress they will develop a holistic approach, which will cause them to synthesize methods of problem investigation and to develop an awareness of the interrelatedness of the various components of systems.

3. The perception of the need for acquired skills will become evident to the students as they become more and more aware of the complexity of natural systems.

4. The responsive awareness will stimulate the students to recognize their responsibilities from a long range point of view. The students will perceive and assume a significant role in society.

5. In particular, the students develop a mature sense of interpersonal relationships which allows them to listen to others and to work effectively as members of teams.

6. Teachers will move from an authoritarian stance to a position where they are able to enjoy learning with students and where they will be able to offer advice and guidance when it is sought by the students.

7. Changes will take place in the present institutions and will be in response to the many positive outcomes generated by the implementation of the above.

Environmental studies programs should be interdisciplinary and should be planned by students, teachers and community members. The participants do not study about environmental quality: they investigate real environmental situations. Multiple references are used rather than a single text.

Participants in environmental studies programs examine their life styles and the ways in which these influence environmental quality. They then work toward the improvement of poor quality environmental factors and work for the maintenance of high quality factors.

In dealing with the manmade and natural environments the primary goal is the development of attitudes and understandings rather than strictly the exposure to information. In formal and nonformal learning situations those involved reach the stage where they are actively seeking answers to questions which they have raised. Constant evaluation and feedback help to develop a process approach, which is not working toward the development of a curriculum or a course of studies. Persons of all age levels are potential participants.

The guide is divided into two volumes: Volume I provides process education activities and Volume II provides seven technical and operational back-up appendices for these activities.

Three levels of activities are provided: those which increase awareness; those which allow students and teachers to take actions related to particular concerns; and those which are on-going problem investigations.

Awareness activities occur at the beginning of each chapter, and they usually require little or no equipment. Awareness activities allow students and teachers to make observations and draw conclusions about real things in their environment. These activities are followed by transitional activities which deal with individualized real concerns that have grown out of awareness activities. The transitional activities prepare the students and teachers for problem investigation activities. Transitional studies allow groups to focus on problems which are more easily defined and which are successfully dealt with within the existing school time structure. This sort of preparation allows the teachers and students to prepare for more complex problem investigations which may not be fully resolved during a formal course of study. The success of the investigation, of course, lies in the process pursued to successfully carry out the investigation and constructively inform the community of the status of the problem.

Volume II contains seven appendices which support the studies. In time, teachers and students should be able to generate activities in their community using Volume I as a guide. At this point, Volume I could be placed in a reserve status. On the other hand, Volume II has a lasting value for several reasons. Appendix 1 consolidates the technical aspects of water quality. As you leaf through Appendix 1 you will find water chemistry, biological references, both flora and fauna, computer programs, and equipment references. Appendix 2, Implementation, outlines techniques for dealing with problems of cost, scheduling, and motivation. Appendix 3, Limitations, deals with problems of time and transportation, methods and equipment, and dealing with others. Evaluation is the subject of Appendix 4; behavioral objectives, both affective and cognitive, are dealt with. Several references are included. Appendix 5, contains a comprehensive annotated bibliography which supplements the specific references in each activity. An asterisk coding system indicates possible multi-copy acquisitions for a community (school) reference center. Delineations are made according to elementary and secondary education emphasis. The last two appendices provide a comprehensive glossary and safety rules, respectively. These may be reproduced in quantity.

Each of the activities is written according to a format which includes the seven parts. The introduction, which briefly describes the activity, suggests the age or grade range for which the activity is best suited. Here you will also find any special equipment or requirements necessary to complete the activity.

The students and teachers are presented with questions which will lead them into activities. This approach was chosen because it allows students to respond as individuals; because it diminishes the authority-figure role of the teacher; and because it implies that there are few-if-any ultimates which can be applied to real world situations. After being led into the investigations the students and teachers will be attempting to answer questions which relate to unsolved problems of society at large. The attempt has been made to develop an approach that will help individuals to work together to improve society. Four categories of questions are used to involve the co-learners in activities.

The questions which lead to the activities are intended to direct thinking toward a general area of investigation. Those to initiate require action if they are to be investigated and help to get the action started. Questions to continue help to give the problem more definition and to allow branching-off points. Those which are used to evaluate help the co-learners to assess the successes and failures and to suggest areas of further investigation.

Sections III and IV of the activities deal with equipment and procedures respectively. The equipment necessary to complete the activity is listed as well as are outlines of events which will probably take place. If branch points are likely, as is often the case, they are indicated. The teacher should try not to steer the activity in one set direction, but rather be ready and willing to allow students to pursue these branch points even if it means that the goal of the original activity is lost for the time being.

The next section on past studies highlights results obtained by using the activity. The activities which have survived the test of practical application should reinforce the teacher's efforts to use them again. Also helpful in this section are descriptions of how the students were evaluated and what outgrowths stemmed from the activity.

A section on limitations has been included for the benefit of the user. Here, the various problems likely to be encountered are listed. Limitations such as costs, extra preparation time, and transportation should be well understood before the activity is used. If any of these limitations appear to create obstacles which in your particular case might inhibit the implementations of the activity you may find some helpful suggestions in Appendix 2.

The last section of each activity contains an annotated bibliography of references which are especially helpful in that activity. Organizations from which you may obtain continuing or new information are also noted here.

Chapter 1 Hydrologic Cycle

Water, one of man's most valuable resourses, moves continually through a cycle from the atmosphere to the earth, over and through the earth, and to the atmosphere.[1] Water quality changes as water moves through the cycle; therefore, an understanding of the cycle enhances an understanding of water pollution and its prevention. Climatology, geology, geography, and petrology, areas of study related to the hydrologic cycle, also aid in this study.

The hydrologic cycle, illustrated in Figure 1-1, shows many repositories for water and the processes which convey the water from one point to another.

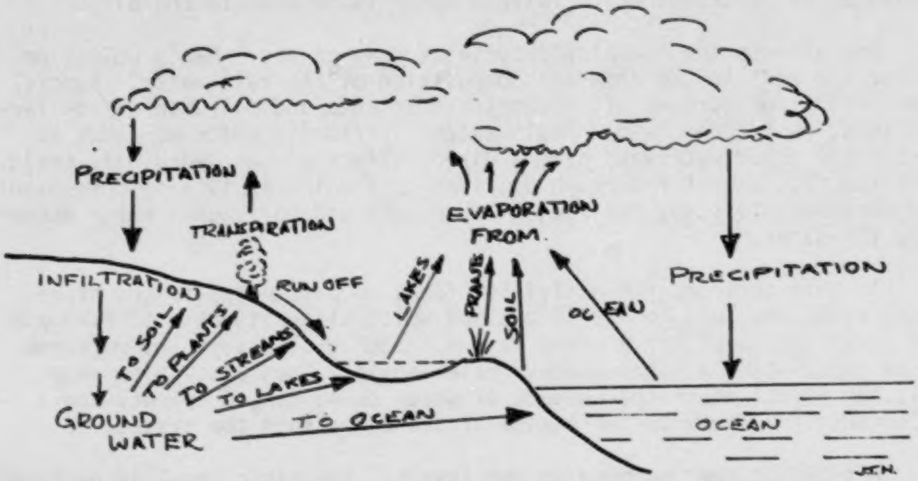
PRECIPITATION
TRANSPIRATION
EVAPORATION FROM
LAKES
PRAIRIE
SOIL
OCEAN
PRECIPITATION
INFILTRATION
RUN OFF
TO SOIL
TO PLANTS
TO STREAMS
TO LAKES
TO OCEAN
GROUND WATER
OCEAN
J.T.H.

Figure 1-1 Hydrologic Cycle Schematic
(From Climate and Man 1941 Yearbook of Agriculture)

The flow of water is made up of many smaller cycles. Rain water can run off into streams and rivers finding its way to the ocean or it can infiltrate the soil or further downward to become ground water, or part of the water table. Water can find its way back to the surface in many ways: it can seep into lakes and streams which are deep enough to extend into the water table; it can surface through springs or wells; it can flow from faults where the underlying strata become exposed, or it can be tapped by the roots of plants.

---

[1] Grover and Harrington, Stream Flow Measurements, Records and Their Uses (New York City: Dover Publications, 1966), p.1.

Hydrologic Cycle

Transpiration, the giving up of water vapor to the atmosphere by plants, and evaporation from land and water bodies also returns water vapor to the atmosphere. The cycle continues when pure water condenses and becomes precipitation.

The cycle is a global cycle, but it can be studied in small regions by measuring inputs and outputs of water from these areas.

As water flows through the various pathways of the hydrologic cycle, its quality is often affected. It may pick up nutrients or pollutants in the form of dissolved solids as it passes through the soil or underlying rocks of a region. While it is in vapor form, water may become contaminated with foreign materials. Evaporation and transpiration are purification processes which release water vapor back to the air.

Man affects the hydrologic cycle at many points. Man's pollution of the air adds to the chemical composition of the rain water. Runoff from fields and gardens often carries nutrients and pollutants from fertilizers, pesticides, and animal wastes. Effluents which man adds to rivers and other waterways have a direct effect on the hydrologic cycle. When the flow of water through a system is studied it is also convenient and necessary to study the flow of nutrients and pollutants which accompany the water.

In this section, the activities focus on parameters of the hydrologic cycle and lead to investigations which allow students to evaluate the total system within a given region. Such evaluations are referred to as calculating a total budget for a locale. Such activities show that the inputs minus the outputs of water containing nutrients and pollutants are equal to the change of storage within the system.

Activities are designed on two levels. The basic level is designed to give the student an understanding of the water flow through an area of the cycle. The advanced level gives an understanding of the nutrients and pollutant-flow which accompany the water. Generally, suggestions for maintaining and continuing activity are concerned with the physical and biological characteristics within the system and lead to man's effect on the system.

Inherent in the following activities is the need for the delineation of a location for study. Any study region is possible if its boundaries are carefully defined. Boundaries include the air above and a specific depth in the ground below unless a smaller region is chosen. A conceptual diagram of the hydrologic cycle of an area of study is outlined in Figure 1-2.

Hydrologic Cycle

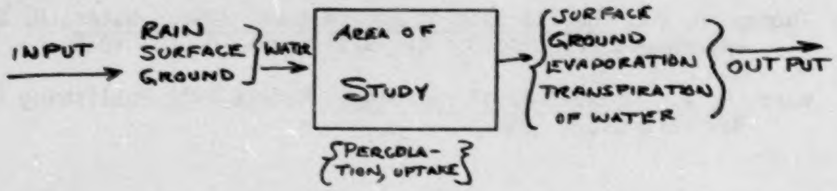

Figure 1-2 Hydrologic Cycle of Study Area

There are few limitations associated with the activities of this section. Most can be carried out by a teacher in any situation. They are capable of being performed on driveways, lawns, and football fields, or in country watersheds. The activities do not encompass all aspects of the water cycle.

The following skeleton questions serve to outline the scope of the section:

1. How much precipitation falls on a particular area? Is it pure water?
2. What happens to the precipitation that falls on soil? Where does it go? How does it change?
3. What role do plants have in the hydrologic cycle?
4. What is the source of water in streams? Does this water naturally contain any nutrients?
5. What is the water and nutrient budget for your study area?

The following resources will be found useful throughout the entire section. Resources of particular interest are listed at the close of each activity.

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Hydrologic Cycle

A. Surface Runoff

I. Introduction

The purpose of this activity is to examine surface runoff and its relation to the hydrologic cycle. The activity can be performed by a wide range of grade levels and in many types of study sites.

II. Questions

1. To lead into the activity, ask students: What happens to the precipitation that falls onto the ground?

2. To initiate the activity, ask students:

    a. Is it possible to collect precipitation after it strikes the ground?

    b. Will some of this precipitation be on the surface?

    c. What is the effect of various surface slopes?

3. To continue the activity, ask students:

    a. What is the chemical composition of surface runoff water?

    b. What is the effect of intensity of precipitation?

    c. What is the effect of soil moisture?

4. To evaluate the student, consider:

    a. With the limitations involved, did the student's method eliminate as many external variables as possible?

    b. How accurate were the measuring techniques?

    c. Did his simulated rain approach a natural condition?

    d. Did the student relate this exercise to the hydrologic cycle and the water quality?

    e. Did the student realize that runoff is only one "fate" of precipitated water which strikes the ground?

III. Equipment

1. Shovel
2. Standard size watertight dustpan or some similar water collecting device
3. Several Number 10 cans at least one of which is marked off in liters and another with holes in the bottom for simulated rainfall
4. A 1000 ml. beaker
5. Meter stick or ruler
6. Brunton compass or clinometer (homemade device for measuring slope is also possible)
7. Funnel and filter paper
8. Flask

IV. Procedure

1. Basic Level
    a. Select a site with a variety of slopes.
    b. Determine an area of 20 $cm.^2$ and excavate a shallow trench on the downhill edge for the runoff collecting device (dustpan, tray, etc.).
    c. Measure angle of the slope with the Brunton compass or clinometer.
    d. Pour one liter of water into a Number 10 can with holes while holding can over the delineated area.
    e. Filter surface runoff collected and measure the volume to get percent of runoff.
    f. Wait 5 minutes and repeat process to get the effect of increased soil moisture.
    g. Select and delineate an adjacent area or similar site with the same slope. Repeat the process using a different intensity of simulated rainfall.

h. Repeat the process in areas of differing slopes.

i. If further studies are desired, repeat the process using different soil types and vegetation.

2. Advanced Level

a. Collect (as before) the runoff from various sites showing differences in ground cover, slope, etc.

b. Using a chemical testing kit, determine and compare the nutrient content of the runoff from these areas.

c. Correlate variable physical and environmental factors with changes in water quality of surface runoff.

V. Past Studies

1. Students have found that the moisture of the soil from previous precipitation can have an effect on the amount of runoff.

2. Students have conducted this activity on driveways, near farm fields, and in various other areas and have seen the effects of automobile emissions, animal wastes, and fertilizers on surface runoff composition.

VI. Limitations

1. Even distribution of simulated rainfall may be difficult to reproduce.

2. In order to cover many variables, teachers may find it convenient to break their class down into small groups, having each assigned an environmental or physical variable to examine, and to pool data later.

VII. Bibliography

Earth Science Curriculum Project, Investigating the Earth, Houghton Mifflin Co., Boston, 1967. (Chapter 9 contains a discussion of the movement of surface and ground water.)

Ward, R. C., Principles of Hydrology, McGraw-Hill Publishing Co., New York City, 1967. This more advanced text gives a stimulating and complete discussion of surface runoff and its relation to the hydrologic cycle.

B. Infiltration and Percolation: Concepts and Measurements Involved

I. Introduction

This activity acquaints the student with the action of water absorption, infiltration, and percolation in soil and encourages him to relate these to the hydrologic cycle and water quality. The basic level activity may be carried out by 7th graders and above; the advanced level may be carried out by students who have a little knowledge of chemistry. The activity will be carried out in a field or on a lawn where digging temporary holes is permissible.

II. Questions

1. To lead into the activity, as students:
    a. What happens to the precipitation that falls on soil?
    b. Where does the water in the soil move and how does it change?
    c. What is the action of water that enters soil?
2. To initiate activity ask students:
    a. How would you determine water motion within the soil?
    b. What determines the direction of water motion? What effect does this movement have on water quality?
3. To continue activity ask students:
    a. Are there any differences in the speed of water motion?
    b. Is there any upward or sideward movement?
    c. Does soil type affect the motion or effects of water in soil?
4. To evaluate the student's performance, consider:
    a. Has he demonstrated soil water movement satisfactorily?
    b. Was he able to relate infiltration to possible changes in water quality?

c. Does he explain where much of the water he uses goes?

d. Is he concerned as to the effects of the use of tracer dye?

e. Does he relate man's activities to a possible role in the quality of infiltrated water?

III. Equipment

1. Basic Level

   a. Digging tools

   b. Nontoxic dye such as fluorescent Pyla-Tel tracer dye (food coloring is also possible)

   c. Several 10-qt. buckets and other large containers

   d. Timing instruments

   e. Meter Stick

   f. Filter paper, Kleenex, paper towels, or toilet paper

   g. Aluminum edging fence

2. Advanced Level

   a. Nonpoisonous leaching chemical, such as sodium phosphate

   b. Funnels

   c. Sample bottles

   d. Hach, Delta or LaMotte kit or suitable qualitative chemistry testing kit

   e. Soil collection bags

   f. Beakers

   g. Pipettes and rubber tubing

IV. Procedures

1. Basic Level

a. Have students set up a 30 cm. diameter circle of aluminum edging fence.

b. Have students calculate how long it takes for a given quantity of water to penetrate the soil after it is poured into the enclosed area.

c. Have students compare times from various areas.

d. Have students excavate a 15 cm. diameter hole, which is 30 cm. or more deep.

e. Have students excavate smaller holes around the original hole at various distances from it.

f. Have students fill the original hole with the tracer dye solution.

g. Have students make periodic checks in the surrounding holes with absorbent papers to determine flow of water and dye.

2. Advanced Level

a. Have students excavate an additional experimental hole and distribute a known quantity of the nontoxic soluble chemical at the base of this hole.

b. Have students add enough water to bring the concentration of the solute to 0.1M in the hole.

c. Have students excavate test holes around the original at various intervals. (between 2 cm. and 35 cm.)

d. After appropriate time delay, have students collect moist soil or accumulated water samples from the surrounding holes. These can be placed in bags and collection can be facilitated with tubing and pipettes.

e. Have students test these samples with chemical testing kits, using the test appropriate for the test chemical used. This can be a qualitative or quantitative consideration. The student should test control samples from the same area.

f. Have students compare and contrast their results.

V. Past Studies

Past studies show that the flow through the soil test holes will be enhanced if they are placed on an incline.

VI. Limitations

1. This activity can be done almost anywhere with simple equipment depending on a teacher's resources.

2. Surrounding holes can be made with an auger and be much smaller if time-saving is a factor. Do not place the surrounding holes too far from the original. Please be sure to get permission of property owners before you go to work.

VII. Bibliography

Monkhouse, F. J., A Dictionary of Geography, Arnold, London, 1965. This gives dictionary meanings of leaching, infiltration, etc., as they pertain to geography.

Strahler, A., Physical Geography, (2nd ed.), John Wiley & Sons, New York City, 1960. This text contains good information on hydrologic cycle and infiltration, with diagrams.

U. S. Department of the Interior, A Primer on Water, U. S. Government Printing Office, Washington, D. C., 1960. This gives very good information on runoff and infiltration under different conditions.

C. Transpiration: The Concepts and Measurements Involved

I. Introduction

This activity enables students to acquire an understanding of transpiration and its relationship to the hydrologic cycle. Seventh graders and above may complete this activity on the basic level.

II. Questions

1. To lead into activity ask students: What is transpiration and how does transpiration relate to the hydrologic cycle?
2. To initiate activity ask students:
   a. Can a way be devised to measure the rate of transpiration and determine the factors that limit it?
   b. How accurate is this method?
3. To continue activity ask students: How would the transpiration rate change in relation to changes in physical factors and man's activities such as air pollution?
4. To evaluate the students' performance consider:
   a. Did the students gain an understanding of the transpiration process?
   b. Did the students devise new tehcniques for demonstrating transpiration?
   c. Did the students relate the process to the hydrologic cycle?

III. Equipment

1. Basic Level
   a. Small potted plant
   b. Bell jar
   c. Flat surface for bell jar such as a glass plate
   d. Plastic sealable bags

e. Small graduated cylinder

f. Sensitive balance or scale (±0.1 g.)

g. Vaseline

2. Advanced Level

a. 500 ml. Erlenmyer flask

b. 2-hole rubber stopper to fit flask

c. Glass tubing

d. 20 cm. of rubber tubing

e. Small leafy plant

f. 1-ml. pipette

g. Burette clamp

h. Ring stand

i. Timing device

IV. Procedures

1. Basic Level

a. Have students place a potted plant under a sealed bell jar.

b. Have students make observations for a short period of time.

c. Have students alter some physical factors and make new observations.

d. Record and discuss all observations,

or,

a. Have students find a tree with leaves low enough to reach.

b. Have each student enclose a leaf in a plastic bag.

c. Have students wait an appreciable amount of time and collect bags.

d. Have students quantitatively determine the amount of water transpired.

e. Have students record and compare results. Ask them where the water came from and where it goes.

2. Advanced Level

   a. Have students set up apparatus as outlined in Figure 1-1.

   b. Have students fill the system completely with water and record the quantity of water used by the plant at various intervals.

   c. Have students graph the data.

   d. Have students repeat the experiment altering some physical factors.

   e. Have students outline the relationship of physical factors to transpiration.

V. Past Studies

1. Students on the elementary and early secondary levels marveled at the collection of water by enclosing a leaf in a plastic bag.

2. Students at the 10th grade level were excited to find that plants give the atmosphere such a large quantity of water. One student devised a quantitative method to measure the amount of water a tree transpired in 24 hours.

3. Students at the 10th grade level were able to qualify the difference in transpiration between shaded and unshaded leaves and leaves of different sizes.

VI. Limitations

There are no limitations foreseen. Teachers should caution their students that procedures calling for sealed containers should be closely followed.

VII. Bibliography

Biological Sciences Curriculum Study, High School Biology, Green Version, (2nd ed.), Rand McNally & Co., Chicago, 1968. This is an easy reading basic biology test. Transpiration is treated on pages 447-449 and includes detailed procedure for a laboratory investigation of transpiration.

De Wiest, R. J. M., Geohydrology, John Wiley and Sons, Inc., New York City, 1965. This is a highly technical treatment of all aspects of the engineer's concerns; however, the treatment of transpiration is brief, simple and useful. (See pp. 47-49).

Hill, J. B., and others, Botany, McGraw-Hill Book Co., New York City. This is a collegiate text but easy enough for the good high school student. There are references to the physiological aspects of transpiration.

Leopold, Luna, and Walter Langbein, A Primer on Water, U. S. Government Printing Office, Washington, D. C., 1960. This is a simple pamphlet with good diagrams which are well worth having in the classroom. It runs the gamut from the water cycle to water purification systems, to farm irrigation, and to legal aspects. Water in relation to plants and soil is treated on pages 26-27.

Morholt, Evelyn, Paul Brandwein, and Alexander Joseph, A Sourcebook for the Biological Sciences, (2nd ed.), Harcourt, Brace & World, Inc., New York City, 1966. This is a must for every biology teacher. Use in this activity for directions for demonstrating transpiration and plant physiology.

U. S. Department of Agriculture, The Yearbook of Agriculture, 1955: Water, U. S. Government Printing Office, Washington, D. C., 1955. This is an excellent reference for the price ($2.00). It deals with water in connection with agriculture, forestry, and wildlife. It is easy reading with good diagrams and lots of statistics, although it is a bit old now.

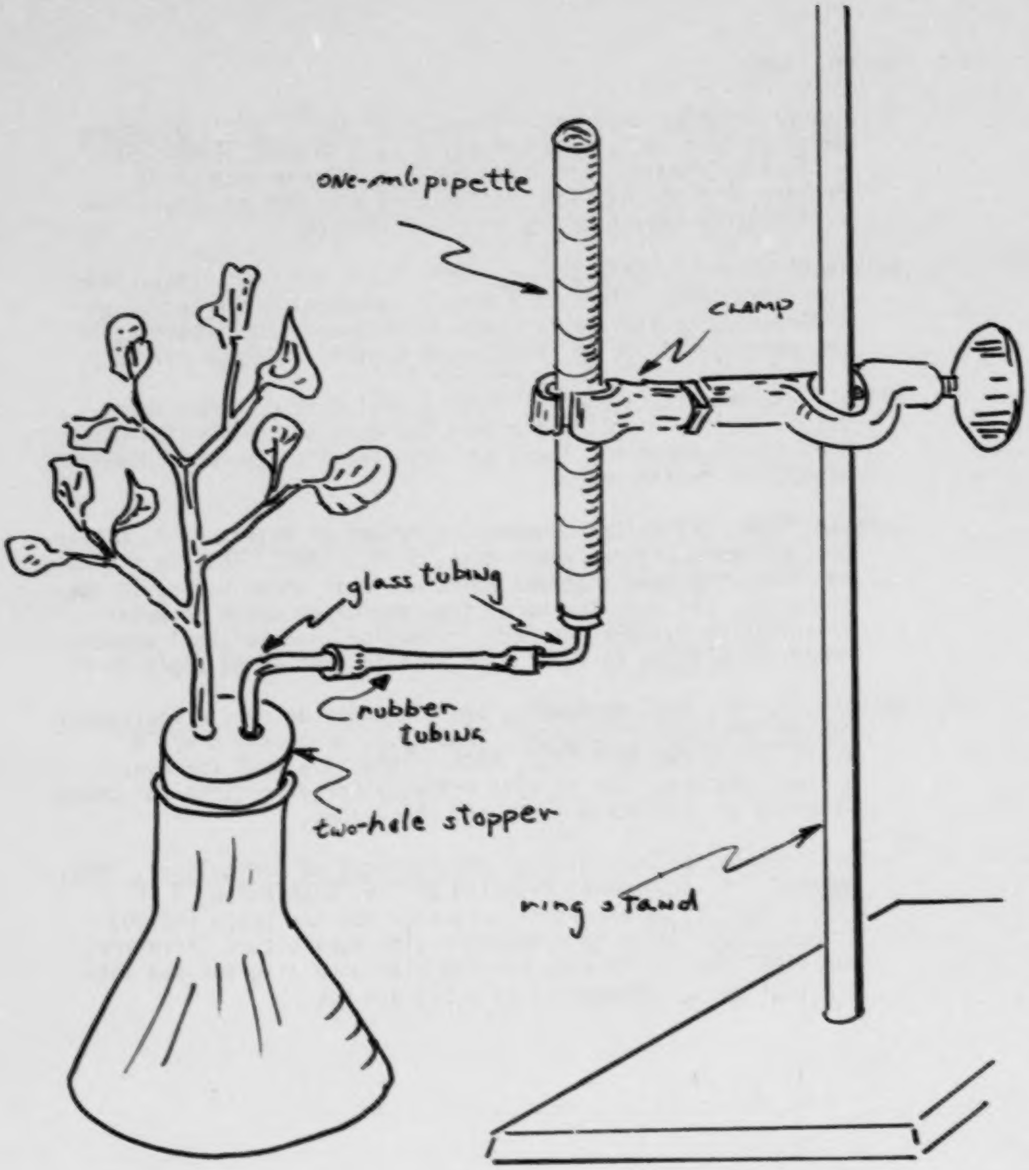
one-ml. pipette
clamp
glass tubing
rubber tubing
two-hole stopper
ring stand

Figure 1-3 Diagram for Advanced Procedure

D. Soil Evaporation and Transpiration

I. Introduction

The purpose of this activity is to provide the student with an understanding of transpiration and its relationship to soil moisture content. It is applicable to a wide range of grade levels and study areas.

II. Questions

1. To lead into the activity ask students:
    a. What happens to the water taken up by plant roots?
    b. Where does it come from?
    c. Where does it go?
2. To initiate activity ask students:
    a. Does the use of soil water by plants have any effect which can be measured in terms of a difference in soil moisture content in a vegetated or unvegetated area?
    b. Does a covering of plants have any effect on the evaporation of moisture from soil?
3. To continue the activity ask students:
    a. How might man's land-use activities affect the hydrologic cycle through an effect on plants and their transpiration?
    b. Is transpiration a "good" or "bad" thing in relation to the role of water in our lives?
4. To evaluate the student's performance, consider:
    a. Does he weigh the idea that vegetation inhibits precipitation runoff with the idea that vegetation increases depletion of soil moisture by transpiration?
    b. Does he realize the multirole of plants in the hydrologic cycle?

III. Equipment

1. A coleus or geranium plant
2. Vaseline

3. Soil auger
4. Plastic bags (sandwich bags are excellent)
5. Trowel or small shovel
6. Balance
7. Meter stick
8. Oven or drying device
9. Six tall juice cans
10. Masking tape
11. Seeds of a convenient plant

IV. Procedure

1. Have the students pick four leaves from the plants.
2. Have the students coat the top side of one leaf, the bottom of another and both sides of a third with vaseline.
3. Have students check the leaves in 24 and 48 hours.
4. Have students discuss the condition of the leaves in relation to the untreated leaf and relate this to the biological role leaves play in transpiration and the water cycle,

or,

1. Have students clear the vegetation from a square of ground which is 30 cm. per side.
2. Have students take soil samples at various depths.
3. Have students determine the moisture content of these samples by weighing, drying, and reweighing.
4. The next day, have students take 3 more samples from the denuded plot and 3 from a vegetated area nearby.
5. Have students determine moisture content of each.
6. Have students discuss the results in terms of the hydrologic cycle and transpiration,

or,

1. Have students place an equal amount of soil in each of 6 juice cans.
2. Have students add an equal amount of water to each and plant seeds in 2 of them.
3. Have students cover all the cans with plastic.
4. When the seeds begin to germinate have students uncover the cans with planted seeds and 2 of the other cans.
5. After 3 days of plant growth, remove the plants and take an equal weight of soil from each of the cans and determine the moisture content.
6. Have students compare the moisture contents of each and discuss the mechanisms which cause different moisture amounts in each of the 3 types of "can" situations.

V. Past Studies

1. Students have been able to show graphically that soil loses more water when vegetated than it does in a denuded area where only evaporation takes place.
2. Students have often been stimulated to argue whether the role of plants is important in the hydrologic cycle. Replacement of atmospheric moisture must be weighed with the importance of soil moisture to man.

VI. Limitations

There are no foreseeable limitations in this exercise although some parts extend over a lengthy time period. A site location and materials collection should be no problem.

VII. Bibliography

Biological Sciences Curriculum Study, High School Biology, Green Version, Rand McNally & Co., Chicago, 1968. This text provides an explanation of transpiration and ideas for developing other demonstration projects.

Leopold, Luna, and Walter Langbein, A Primer on Water, U. S. Government Printing Office, Washington, D. C., 1960. An excellent pamphlet which deals specifically with the relation of plants, transpiration, and soil moisture.

Hydrologic Cycle

Morholt, Evelyn, Paul Brandwein, and Alexander Joseph, A Sourcebook for the Biological Sciences, Harcourt, Brace & World, Inc., New York City, 1966. This reference treats the physiology of transpiration.

Ward, R. C., Principles of Hydrology, McGraw-Hill Publishing Co., New York City, 1967. This advanced but excellent text gives a complete and stimulating coverage of transpiration and its relation to the hydrologic cycle.

Wilson, Carl, and Walter E. Loomis, Botany, Holt, Rinehart and Winston, New York City, 1962. A standard reference for botany, this text treats the biology of transpiration.

E. Evapotranspiration

I. Introduction

The purpose of this activity is to show that on a small grassy area water leaves the grass and enters the atmosphere by the process of evapotranspiration. It is a suitable activity for a beginning study of the hydrologic cycle. Seventh graders can easily do this study and young students will enjoy it if the teacher helps them with the water testing.

II. Questions

1. To lead into the activity ask students:
    a. Have you ever noticed water collecting on the underside of a waterproof material after it has been on the ground?
    b. Where did this water come from?
2. To initiate activity ask students: Can you collect and/or measure the water from the underside of a waterproof material after letting the material lie on a grassy area in the sun?
3. To continue the activity ask students:
    a. How does the process of transpiration fit into the hydrologic cycle?
    b. Do you think transpired water is pure?
    c. Is this important?
4. To evaluate the students performance consider:
    a. Does the student seem to understand the concept of transpiration and its relation to the hydrologic cycle?
    b. Did he develop additional approaches and techniques for demonstrating and measuring transpiration?

III. Equipment

1. A plastic sheet (preferably mounted on a stiff form, such as a form cut from a cardboard box and a clear sheet of plastic or cellophane stapled to its edges works well)

2. A small container to collect water from the plastic
3. Water testing kit for advanced study

IV. Procedure

1. Place the collecting equipment on grass, preferably in sunlight, and leave it there for 30 minutes or more.
2. Collect or observe droplets of moisture which have collected on the underside of the plastic.
3. If enough water is obtained, chemical testing procedures may be employed to determine such factors as total dissolved solids.

V. Past Studies

Students in many situations have been able to appreciate the demonstration of transpiration and its relationship to the water cycle by using this experiment.

VI. Limitations

There are no limitations in this experiment.

VII. Bibliography

Earth Science Curriculum Project, Investigating the Earth, Houghton Mifflin Co., Boston, 1967. This standard text gives a short treatment of transpiration on p. 215.

Ward, R. C., Principles of Hydrology, McGraw-Hill Publishing Co., New York City, 1967. This excellent text gives a coverage of evapotranspiration and its relation to the hydrologic cycle. Many ideas for continuing study projects can be found.

Wilson, Carl, and Walter E. Loomis, Botany, Holt, Rinehart and Winston, New York City, 1962. A standard botany text, this source covers the biology of transpiration.

F. Infiltration: Its Effect on Water Quality

I. Introduction

This activity demonstrates the change in precipitation water quality as it passes through soil using a lab model. This activity is applicable to a range of grade levels. Seventh graders can complete this activity if the teacher assists with the dissolved solids tests. Students with some chemistry background can do the activities themselves.

II. Questions

1. To lead to the activity ask:
   - a. What happens to rainwater after it strikes the soil?
   - b. Does some soak in?
   - c. Does this change its quality?
2. To initiate the activity ask:
   - a. How any quality change that occurs during infiltration may be measured?
3. To continue the activity ask:
   - a. What would the variance in change be if two samples of different soil composition were tested?
   - b. What would happen in test areas of different vegetation?
4. To evaluate the student's performance consider:
   - a. Was he effective in using testing equipment and becoming skilled in testing techniques?
   - b. Was he able to decide on logical choices for dissolved solids tests for his type of soil?
   - c. Was he eager to improve on the experiment and make attempts to devise new experiments for testing changes in precipitated water quality?
   - d. Did he check the distilled water to find the pH and any minerals which were already present?

III. Equipment

1. Chemical testing equipment
2. Sample box with screened bottom
3. Shovel
4. Collecting pan
5. Rainwater or distilled water
6. Number 10 can
7. Funnel (optional)
8. Ringstand (optional)
9. Funnel holder (optional)
10. Filter paper (optional)
11. Beakers (optional)
12. Number 10 nail or punch

IV. Procedures

1. Take a soil sample from the area chosen for study. Soil samples can be up to one cubic foot (30 - 45 kilograms). Bring the sample back to the lab.
2. Spread the sample in the sample box with the screened bottom.
3. Make a rain simulator by taking a Number 10 can and perforating the bottom with a nail or punch.
4. Measure out one liter of the test water.
5. Simulate rain on the soil sample by pouring your liter of water into the perforated can and collecting the seepage in a collection pan placed below the screened box.
6. Do appropriate dissolved solid tests on the seepage collected.

V. Past Studies

1. Some students recorded high iron and copper content in seepage water until they realized that their screening was affecting their results.
2. Students discovered that filtering seepage resulted in facilitating colorimetric chemical testing.
3. Some students have used rainwater in conducting the experiment. By testing water quality of rainwater and seepage, a more realistic presentation of the effect of infiltration on water quality was found.

VI. Limitations

1. This exercise requires a general knowledge in recognizing dissolved solids and testing for them. Teachers should let their students decide on the appropriate dissolved solids tests for the soil sample collected.
2. Careful rain simulation is necessary for realistic and uniform distribution.
3. Sites should be chosen that are representative and easily accessible.

VII. Bibliography

Leopold, Luna, and Walter Langbein, A Primer on Water, U. S. Government Printing Office, Washington, D. C., 1960. This inexpensive pamphlet contains a good description of infiltration in various conditions.

Strahlet, A. N., Physical Geography, John Wiley & Sons, Inc., New York City, 1960. This reference contains good general information on the hydrologic cycle and infiltration diagrams.

Ward, R. C., Principles of Hydrology, McGraw-Hill Book Co., New York City, 1967. An excellent general source, this text contains a detailed and stimulating coverage of infiltration and its relationship to water quality and the hydrologic cycle.

G. Ground Water Seepage

I. Introduction

This activity demonstrates that rock and soil minerals are dissolved in water as it moves from the surface to ground water and relates these nutrient changes to the water cycle. Students in a range of grade levels may complete this activity as the extent of testing is adaptable to the ability of the group. Any area where ground water seeps to the surface or is otherwise available for collection is a possible study site.

II. Questions

1. To lead into the activity ask students: Does water quality change when it soaks into the ground?
2. To initiate the activity ask students:
   a. Where can we collect ground water samples?
   b. How can we determine the composition of the water quality change?
3. To continue the activity ask students:
   a. How does the change in water quality take place?
   b. If this type of solution continues, what will happen to the soil and rocks of the area?
4. To evaluate the student's efforts consider:
   a. Has the student demonstrated how and why seepage water is of different composition than surface or rainwater?
   b. Has the student made any reasonable conclusions as to where the dissolved materials in the seepage water will finally accumulate?
   c. Does the student relate leaching to a role in the changing water quality and nutrient composition in the hydrologic cycle?
   d. Does the student realize that infiltration can also be a water purification mechanism?
   e. Does the student relate man's activities and their possible effect on the quality of ground water?

III. Equipment

1. 5 to 10 collection bottles (sterile)
2. Water chemistry testing kit (qualitative or quantitative)
3. Water bacterial analysis materials

IV. Procedure

1. Select an area of rock or soil where seepage of ground water to the surface is evident.
2. Collect 5 to 10 bottles of water for water chemistry and bacterial tests.
3. Test the water qualitatively or quantitatively as time and resources permit.

V. Past Studies

Students and teachers have found that if areas of ground water seepage are inaccessible, an examination of well or spring water is feasible.

VI. Limitations

The major limitation of this activity is the determination of a site with suitable flow for study; however, such seepage is found throughout the country.

VII. Bibliography and Resources

Baldwin, Helene I., A Primer on Ground Water, U. S. Government Printing Office, Washington, D.C., 1963. This is an excellent pamphlet for introductory treatment of ground water.

Ward, R. C., Principles of Hydrology, McGraw-Hill Publishing Co., New York City, 1967. This somewhat advanced text gives a complete coverage of ground water and contains ideas for stimulated students to develop into projects.

Teachers are also advised to contact their state and local Federal agencies for information on ground water resources of particular areas. The Soil Conservation Service is a particularly helpful agency.

H. Transpiration and Plant Uptake

I. Introduction

This activity is designed to help students realize that water is being taken in and given off by plants as part of the water cycle. It can be carried out in varying degrees beginning at the 1st grade level. Few time and travel problems occur because local weeds, shrubs and trees may easily be found in the immediate area.

II. Questions

1. To lead into the activity ask:
    a. What happens to a plant if it is not watered?
    b. Why do plants have to be watered more than once?
    c. What is happening to the water?
2. To initiate the activity ask:
    a. How is water released from the plant and why don't we see it?
    b. How can we show that water is being given off?
    c. How can we measure how much water is being given off?
3. To continue the activity ask:
    a. If a small plant gives off a given amount of water, how much does an oak tree give off?
    b. How much would a forest give off in a certain time period?
    c. Are the biological activities of plants involved in pollution?
    d. Does a given plant give off an equal amount of water from day to day or under variable physical conditions?
4. To evaluate the student's performance consider:
    a. Did the student devise methods for measuring the uptake and release of water by plants?
    b. Were his techniques successful in visibly demonstrating transpiration?

c. Did the student realize the role of plants in the hydrologic cycle and possible pollution from plants in a natural environment?

III. Equipment

1. Plastic bags (one per student)
2. Twist wires for tightening bags around plant stems
3. Bucket
4. Graduated cylinder or some equivalent means of liquid measure
5. Spade
6. Aluminum foil

IV. Procedures

1. Transpiration activity

   a. Locate a place on your campus where there are small plants with stems so structured that plastic bags can be slipped over the end. Weeds are ideal (e.g., milkweed).

   b. Have each student slip his bag over the end of a stem so that it will cover as many leaves as possible. Use the twist wires to tighten the open end around the stem securely.

   c. Have the students return the next day and cut off the stem with the bag on it. Bring it back to the classroom and measure the amount of water that has collected in the bag.

2. Plant Uptake Activity

   a. Have the students dig up two or more plants, getting as much of the root system as possible. Remove all soil from the roots and place each in a bucket containing a measured amount of water covering the roots.

   b. Have the students check the amount of water in the bucket at various later times.

V. Past Studies

1. Students have found that they can demonstrate transpiration using a plant under a bell jar.

2. Although students at a particular school found that evaporation from all the plant uptake buckets was uniform, they devised a method using aluminum foil for eliminating evaporation as a variable.

3. Other students placed transparent plastic sheets on their lawn and observed the transpired water collecting under them.

VI. Limitations

1. Teachers should try to prevent other students at the school from disrupting the transpiration experiment.

2. Teachers can avoid problems by locating suitable plants on their campus before the students begin work.

VII. Bibliography

Biological Sciences Curriculum Study, High School Biology, Green Version, Rand McNally and Co., Chicago, 1968. Written for the high school level, this text contains a description of transpiration and ideas for further experiments.

Ward, R. C., Principles of Hydrology, McGraw-Hill Publishing Co., New York City, 1967. This excellent, more advanced reference contains a stimulating discussion of transpiration and its relation to the water cycle.

Wilson, Carl, and Walter E. Loomis, Botany, Holt, Rinehart and Winston, New York City, 1962. A standard botany text, this reference contains information on the biology of transpiration.

I. Erosion: The Effects of Water on Soil

I. Introduction

The purpose of this activity is to demonstrate the erosion effects of water runoff on various types of soil and slopes. It is a possible "beginning" activity for students at any level of understanding and is capable of being performed on any nearby eroded area.

II. Questions

1. To lead into the activity:
    a. Are there any hills or cliffs in your area that are being eroded?
    b. How does the runoff water affect these hillsides?
    c. Does the type of soil composition have any effect on the erosion rate?
2. To initiate activity:
    a. What soil composition do these hills have?
    b. What is the slope of these hills?
    c. How can we measure the ability of water to change the structure of different soils on a slope?
3. To continue activity:
    a. What types of plant life, if any, are found on these hillsides?
    b. Are similar types of plants found in all soil types?
    c. How does plant growth seem to affect erosion?
    d. How can the amount of rainfall be measured on individual hills?
    e. How can erosion rates be determined?
    f. What are other physical factors in erosion?
4. To evaluate the students' performances:
    a. Were the students able to identify various soil types as to their resistance to erosion?

b. Were the students able to correlate slope to erosion?

c. Did the students recognize the forces other than water which act upon the soil?

III. Equipment

1. Rain gauge
2. Meter stick
3. Protractor or clinometer
4. Stakes
5. Hammer

IV. Procedures

1. Have students visit the erosion site and set up rainfall gauge.
2. Have students drive measured stakes into the ground at the top, middle, and bottom of the area.
3. Have students measure the slope of the area.
4. Have students describe the soil of the site.
5. Have students examine and describe the plant life of the area and the root structure of particularly abundant species.
6. After the next rainfall, have students visit the site and repeat the previous procedures.
7. Have students calculate the amount of soil eroded off a specific area using the comparative before-and-after measurements from their stakes.
8. Have students correlate the amount of rainfall, slope, vegetation, etc., with the amount of erosion.

V. Past Studies

1. Students have often been amazed at the amount of soil which can erode off an unprotected hillside in a single rainstorm.
2. Some studies have included graphs correlating slope with amount of erosion.

3. Students have often been impressed at the amount of solid material that may enter a stream from such a hillside. The link between erosion and water pollution becomes visibly evident.

VI. Limitations

1. Teachers may have difficulty finding a site suitable for study. Housing developments and road construction areas can suffice, though open mining pits and steep unprotected hillsides usually provide the best study sites.

2. There are few other limitations to the study although the time period should be noted as this is a continuing study.

VII. Bibliography

Coleman, Edward A., Vegetation and Watershed Management, Ronald Press Co., New York City, 1953.

Earth Science Curriculum Project, Investigating the Earth, Houghton Mifflin Co., Boston, 1966. This text contains a description of water forces and their cause of erosion.

Ward, R. C., Principles of Hydrology, McGraw-Hill Book Co., New York City, 1967. This rather advanced reference contains a readable and stimulating treatment of water runoff.

J. Diffusion: Demonstration of Water's Solvent and Diffusion Properties

I. Introduction

The purpose of this activity is to demonstrate the diffusion of materials in water. Being a lab activity it is easily applicable to most teaching situations and a range of grade levels.

II. Questions

1. To lead into the activity:
    a. What is water?
    b. What is a solvent?
    c. What is diffusion?
    d. Is it possible to use elements, compounds, or both, to demonstrate diffusion and the rate of diffusion?
2. To initiate activity:
    a. How long does it take for differing chemicals to diffuse in water?
    b. Is there a difference in their diffusion rates?
3. To continue activity:
    a. Is there a noticeable difference in diffusion of organic and inorganic chemicals in water?
    b. How do effluent wastes from man's activities diffuse?
4. To evaluate the student's performance consider:
    a. Did the student relate diffusion to water pollution?
    b. Did the student realize the importance of water's solvent properties in the hydrologic cycle and water pollution?
    c. Did he demonstrate varying differences in diffision rates of various test compounds he chose?

III. Equipment

1. Suitable test chemicals such as potassium permanganate ($KMnO_4$), copper sulfate ($CuSO_4$), iodine, and elemental iron
2. Beakers and flasks

3. Effluent wastes from man's activities such as water from washing or cooking vegetables, sludge from a sewage plant, factory effluents from local industries, animal wastes from barns, detergents, etc.

4. Stopwatch

5. Bunsen burner, ring stand, asbestos screen

6. Balance

7. Filter paper

IV. Procedures

1. Add crystals or drops of test chemicals to beakers of water.

2. Observe and time the rate of diffusion throughout the solvent.

3. Have the students do the same with the various test effluents they have selected.

4. If students select a test material which does not completely dissolve, have them separate the undissolved material; dry and weigh it to determine the percentage of their material which has diffused.

V. Past Studies

Students have easily been able to relate what they have seen in this activity in the laboratory to what they see as effects of man on local rivers.

VI. Limitations

Teachers should caution their students about the dangers involved in the use of sewage wastes.

VII. Bibliography

Earth Science Curriculum Project, Investigating the Earth, Houghton Mifflin Co., Boston, 1966.

Leopold, Luna, and Walter Langbein, Water, Time, Inc., New York City, 1968.

U. S. Department of Agriculture, The Yearbook of Agriculture, 1955: Water, U. S. Government Printing Office, Washington, D. C., 1955.

K. Ground Water: An Examination of the Source of Water in Streams

I. Introduction

The purpose of this activity is to examine ground water as the source of water in streams. This activity is recommended for the high school level where it can be conducted successfully after the location of a small stream which is convenient for study. This activity requires more than an hour and one-half to complete.

II. Questions

1. To lead into the activity:
    a. Where does stream water come from?
    b. What is ground water?
2. To initiate activity:
    a. How can one demonstrate ground water as the possible source of water in streams?
    b. How does one collect ground water?
    c. What is contained in ground water?
3. To continue activity:
    a. How does the ground water differ at various points along the stream?
    b. How does the terrain affect the ground water?
    c. What other factors might affect the ground water?
4. To evaluate the student's performance:
    a. Does the student understand the relationship between ground water and stream water?
    b. Does the student relate man's activities to a possible role in the pollution of ground water?
    c. Has the student demonstrated the source of water in the stream picked for study?

III. Equipment

1. Core sampler
2. Sledgehammer
3. Shovel
4. Thermometer
5. Siphon or ladle
6. Sample bottles
7. Meter stick
8. Filtering equipment
9. Dissolved solids water chemistry testing kit

IV. Procedure

1. Have the students excavate test holes in the land beside a stream. These can be placed at varying distances away from the stream.
2. Have the students measure the depth to which water fills these holes.
3. Have the students take samples of the water from various test holes.
4. Have the students test the composition of the water from their test holes. Hint: To use colorimetric testing procedures, filtering or centrifuging of the samples may be necessary.
5. Have the students compare the composition of the water from their test holes with a sample taken from the stream itself.

V. Past Studies

1. Students often have found that by placing their test holes too far from the stream they were unable to obtain any water samples. A graphic illustration of the concept of a water table was thus evident.
2. In some situations students were able to see that the water depth in their test holes was very close to that of the stream.

3. Comparable water quality composition from the test holes and stream is often found, indicating a common source. Students have extrapolated that the water in the stream is most probably from the water table they isolated in their test holes.

VI. Limitations

1. Teachers may have trouble finding a stream convenient for this study. However, any small stream will do. Those without steep banks are particularly useful as the students will have a large area of lowland in which to dig their holes with a probability of obtaining water in them.
2. Filtering and centrifuging the water samples is often necessary as the suspended solids content of the samples is often high. This can be done with standard equipment.
3. Students should not be discouraged if there is not immediate filling of their test holes. The holes may not be deep enough!
4. Core samplers have a habit of clogging. Patience is required.

VII. Bibliography

Ward, R. C., Principles of Hydrology, McGraw-Hill Publishing Co., New York City, 1967. Stimulating ideas and explanations of ground water and stream source are found in this somewhat advanced but easily readable reference.

L. Precipitation: Measurement and Evaluation

I. Introduction

This activity introduces the student to precipitation in the hydrologic cycle as the input of water and input vehicle of nutrients to a study area. It is a possible study for all grade levels and is capable of being performed anywhere it rains.

II. Questions

1. To lead into the activity:
    - a. What is rain and how does it form?
    - b. What does it contain or is it pure?
2. To initiate activity:
    - a. How can we collect and measure the amount of precipitation that falls on a particular area?
    - b. What is the water quality of the precipitation?
3. To continue activity:
    - a. What role does the chemical and nutrient composition of precipitation play in the system?
    - b. By what means does precipitation pick up dissolved chemicals?
    - c. Does the composition of snowfall resemble the composition of rain?
    - d. What other means of nutrient input to study areas are there?
4. To evaluate the student's performance:
    - a. Did the student devise a means of collecting precipitation so that he could accurately determine the amount and quality of the sample he obtained?
    - b. Did the student understand the role of the nutrient input of precipitation as far as the system and its ecology is concerned?

   c. Did the student demonstrate the presence of dissolved solids in precipitation?

III. Equipment

1. Basic Level
   - a. Funnels
   - b. Collection bottles
   - c. Evaporating dishes
   - d. Bunsen burner
   - e. Large, flat procelain dishes up to one inch deep
   - f. Rulers
2. Advanced Level
   - a. Demineralizing water wash bottles
   - b. Chemical testing kit for water quality determination

IV. Procedures

1. Basic Level
   - a. Have the student collect precipitation in procelain pans.
   - b. Have the student calculate how much has fallen in inches.
   - c. Have the student evaporate to dryness some of the collection and observe the residual solid content.
2. Advanced Level
   - a. Have the student rinse all apparatus with distilled and then with demineralized water.
   - b. Have the student collect precipitation as above.
   - c. Have the student quantitatively analyze the nutrient content of his collection.

V. Past Studies

1. Students have been able to compare the composition of precipitation from open areas, under trees, near factories, etc., and through discussion, have been able to realize the effects of these physical and biological characteristics on the system.

2. Students have often been able to gain an appreciation of nitrogen cycle by measuring nitrate input in precipitation.

3. Students have found nitrate, sulfate, chloride, fluoride, pH, and total dissolved solids, particularly useful determinations in chemical testing.

4. Students often have shown interest in developing new methods of precipitation collection.

VI. Limitations

1. There are few limitations in this study, particularly since it is capable of being performed on two levels or more.

2. It can be completed almost anywhere.

3. Teachers should make sure that all apparatus used in advanced study has been thoroughly rinsed and demineralized. After such a process it should not be touched as even the dissolved solid content of sweat may affect results.

4. The nutrient content of rain is often very low.

5. The precipitation should be transferred to collection bottles soon after its collection, as evaporation from collection pans will concentrate nutrient composition abnormally.

VII. Bibliography

Borman, F. H., and G. E. Likens, "Nutrient Cycling," Science, 27 January 1967, 155:424-429. This article gives a scientific but easily readable treatment of the role of precipitation in nutrient cycling.

Fisher, D. W., *et al*, "Atmospheric Contributions to Water Quality of Streams in Hubbard Brook Experimental Forest, New Hampshire," Water Resources Research, October, 1968, 4:1115-1126.

Hydrologic Cycle

Likens, G. E., et al, "The Calcium, Magnesium, Potassium, and Sodium Budgets for a Small Forested Ecosystem," Ecology, Late Summer, 1967, 48:772-785. This is a scientific but stimulating review of precipitation collection procedures.

Ward, R. C., Principles of Hydrology, McGraw-Hill Book Co., New York City, 1967.

M. The Water Budget of a Small Watershed

I. Introduction

The purpose of this activity is to introduce the student to the hydrologic and nutrient cycle budgets of a small watershed. It is an advanced-level study and is best attempted by the student who has completed a number of the hydrologic cycle activities.

II. Questions

1. To lead into activity:
   a. If we outline any particular area of land, what are the mechanisms by which water enters that area?
   b. What are the mechanisms by which it leaves the area?
   c. What changes are seen in the form of water while it is in the area?
2. To initiate the activity:
   a. On a particular area of land, what is the total yearly input of water?
   b. What is the total yearly output of water?
   c. By what mechanisms does water enter and leave the area?
3. To continue the activity:
   a. Within the particular area, what nutrients enter and leave using the hydrologic cycle as a vehicle?
   b. What physical and biological characteristics of the system affect the amount of water and nutrients flowing through it?
   c. Is it possible to calculate a nutrient and water budget for the area of study?
4. To evaluate the student's performance consider:
   a. Although it will be unusual to have calculated a balanced watershed budget, does the student display an understanding of such a budget?

b. Did the student realize that the input minus the output equals the change in storage within the system?

c. Were the techniques and references used by the student to calculate input and output reasonable and successful?

d. Did he realize that a long term study is essential for an accurate calculation of a hydrologic or nutrient budget?

e. Was he aware of the discrepancies involved in such an activity and did he attempt to explain them?

III. Equipment

1. References of climatological and hydrological data for the area of study
2. Equipment for measurement and testing of precipitation, transpiration, evaporation, and flow which has been outlined in previous activities and which depends on the number of parameters the student chooses to study within the particular area
3. Topographic maps and long-distance measuring devices

IV. Procedures

1. Have the student delineate an area for study.
2. Have the student calculate the area of his system.
3. Have the student calculate the yearly precipitation input.
4. Have the student identify and measure other system inputs.
5. Have student identify and measure other system outputs.
6. Using extrapolation techniques and his own and reference data, if available, have the student calculate the hydrologic budget for the area.
7. Have the student collect samples of water from various inputs (e.g., precipitation) and outputs (e.g., outflow).
8. Have students chemically analyze the water quality for nutrients.
9. Using extrapolation techniques and his own and reference data, if available, have the student calculate the nutrient budget of the area.

V. Past Studies

1. Students in one study were surprised to see that the sulfate input of their precipitation was nearly equal to the output in the outflow but that most of the nitrate input of precipitation remained within the system.

2. Calculated budgets have often been "unbalanced" by as much as 50%, but students have often been stimulated by the questions of what happened to all the precipitation that fell, and why is this stream still running in such a period of drought.

VI. Limitations

1. The study will be much facilitated if the teacher encourages students to delineate small natural watersheds as their area of study.

2. Teachers may have trouble locating a watershed which is both small enough for feasible study and which has a flowing stream in it.

3. This activity is most valuable as the culminating experience in an examination of hydrology. Students are able to put as many previously learned techniques and understanding to work as they can.

4. Teachers should not forget the importance of continuing data collection in the study of this type. If this can be arranged, the activity becomes a continuing one and its value will be greatly enhanced. If this cannot be arranged, an understanding of the concepts involved is very possible, but the quality of the budget calculated will inherently be low.

VII. Bibliography

Borman, F. H., and G. E. Likens, "Nutrient Cycling," Science, 27 January 1967, 155:424-429. This is a scientific but readable account of the concepts and work which has been done in this area at Hubbard Brook Experiment Forest in New Hampshire. The study is a continuous one and the motivated student will find further references in its bibliography and in more recent publications.

Ward, R. C., Principles of Hydrology, McGraw-Hill Book Co., New York City, 1967.

Chapter 2 Human Activities

Any human activity involving water, affects the hydrologic cycle. Therefore, it is important to see how man's activities cause changes and it is important to evaluate these changes. In many cases there is a pressing need to reverse damage now being done and to correct the errors of the past. These activities show how the individual, the family, and the community affect our water resources.

Today, individuals consume and discharge water in greater quantities than ever before. However, today most people obtain a quality of water that is offered to them by a central supplier in the community. In a similar manner, their waste water is discharged into a community service system. In effect, the individual may control his supply and disposal of water only in an indirect manner. He many not wish to pollute the nearby lakes and streams but if his sewage is processed centrally he cannot prevent the polluting unless he can exert enough political or economic force to redirect the efforts of his community.

Industry has developed in the United States as an extension of the concepts which operated during the great westward movement. Pioneering and carving out an existence by overcoming and utilizing the environment are second nature to many Americans. The concept that America's resources are limitless and require no management is typified by the inaction of industry and local governments to voluntarily correct present pollution practices.

If this attitude is to be corrected, it must be realized that any decision which affects the natural environment, affects an essentially fixed resource. All of us must now accept the principle that we must pay for what we use, whether we use up this fixed water resource in our recreation, our sewage disposal, industrial production, or our consumption of electricity. That we use our environment is necessary and acceptable. However, the future must differ from the past in that we can no longer only take from our environment but must perpetually renew and reuse what we take rather than follow the old pattern of using and discarding.

The activities in this chapter are classified under three major areas of inquiry: social configurations, economic endeavors, and recreational pursuits. The economic endeavors of man are considered on several levels according to the magnitude of the enterprise. We made the following distinctions: proprietorships, small industry, specialized industry, and conglomerates. A series of activities is also included to show the relationships between these areas of human activitity and also relate them to other chapters in the guide.

Human Activities

The following general questions may serve to focus on the scope of inquiry in this chapter. Let "X" equal the particular human activity under investigation.

1. What is the influence of "X" on the nitrogen cycle in your area?
2. What is the influence of "X" on the hydrologic cycle in your area?
3. How do the economic factors of "X" influence its impact on environmental quality?
4. What is the general public's attitude toward the impact "X" has on the environment?
5. What is the legal situation pertaining to "X"? Are the laws sufficient to preserve the environment? Are the enforcement procedures adequate?
6. What are the roadblocks to the lessening of "X's" impact on the environment?

The following resources will be found useful throughout the entire section. Resources of particular interest are listed at the close of each activity.

Billings, W. D., Plants, Man and the Ecosystem, Wadsworth Publishing Co., Belmont, California, 1970.

Life Science Library, Ecology, Time, Inc., New York City, 1969.

McKee, J. E., and H. W. Wolf, Water Quality Criteria, (2nd ed.), State Water Quality Control Board, Sacramento, California, 1963.

A. Farming and Water Quality

I. Introduction

1. The purpose of this investigation is to involve students in a study of how farming in general and on a given farm in particular, affect water quality. In this case we are looking at the effects of agriculture on the water cycle.

2. Any secondary student who has knowledge of the nitrogen cycle should be able to succeed in at least the introductory level of this activity.

3. The activity would take at least 3 hours to complete, and could be spread over a short field trip and several class sessions. The more advanced activities would take a much longer period of time to complete.

II. Questions

1. To lead into the activity, ask students what the nitrate level is in the wells and surface waters on the farm.

2. To initiate the activity, ask students:

    a. How are these data going to be obtained?

    b. What sampling techniques are going to be used; and what are the effects of high nitrate?

3. To continue the activity, ask students: What are the factors in farming practices that might lead to nitrogen in farm water?

4. To evaluate the students' performance ask:

    a. What were the nitrate levels on various areas of the farm?

    b. What factors caused these nitrate levels?

    c. What are the effects of agriculture on the nitrogen cycle?

    d. Can we "afford" to have these effects?

III. Equipment

1. Introductory Level

   a. Hach or Delta kit to determine dissolved solids (can ascertain nitrate or nitrite levels)

   b. Sample bottles

2. Advanced Level

   a. Hach or Delta kit

   b. Pipettes, burets (titration equipment to do analytical techniques)

   c. Millipore apparatus to do coliform and fecal coliform counts.

   d. Plankton net and collection bottles

   e. Soil test kit

IV. Procedures

1. Introductory Level

   a. Use Hach or Delta kit to determine nitrate and nitrite levels in well water, drinking water (if different) and any surface water (ponds or streams) that are on or near farm property.

   b. Find out by asking the farmer what kind and generally how much fertilizer he has put on land.

   c. Find out if there are any feedlots or other collections of animal waste, and if so, how large they are, etc.

   d. Determine amounts of nitrogen that are in the soil.

   e. What is the relationship between nitrogen content of the soil and nitrogen content of water?

2. Advanced Level

   a. Determine the nitrite, nitrate, and ammonia levels in wells and surface waters near farm diurnally and seasonally.

b. Determine variation of flow rate of streams, etc.

c. Determine bacteriological content of abovementioned waters and how they vary.

d. Determine algal content of surface waters near or on farm.

e. What is the effect of various crops on the nitrogen cycle?

f. Does the kind of livestock being raised on the land affect the nitrogen level of the soil and watershed?

g. Is there a difference in nitrate level between the runoff water and the soil?

h. Is there any correlation between fertilizer practice and nitrogen content?

i. Does it matter when the fertilizer is applied?

j. Is there any correlation between high bacteria counts and algae content?

k. Where is the runoff from the feedlot (or manure pile) going? What effect does this have on water quality? On the nitrogen cycle?

l. Be able to ask and answer more sophisticated questions.

V. Past Studies (An Example of a Study)

A study was performed on the Swain, Connely, and Hershey farms in June of 1970. The study was performed to determine the effect of agriculture on the nitrogen cycle. The amounts and kinds of fertilizer added to the farms are listed in Table I.

Farm	Kind of Fertilizer	*Amount Added	Crop
Swain	Manure & 10-20-10	600 lbs./acre	Corn
Hershey	Manure & 15-10-10	600 lbs./acre	Corn
Connely	Manure & 15-10-10	600 lbs./acre	Corn

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*The amount of fertilizer added was the commercial fertilizer added. It was impossible to determine the manure added. Mr. Swain estimated the amount of manure added was 20 tons/acre/year.

The Swain farm had no surface or well water. All of its water was piped in from Tilton.

The Hershey and Connely farms obtained their water from wells. Table II shows the results of tests run on the water and soil from these two farms.

Table II Hershey-Connely Farms

	Nitrate	Nitrate Nitrogen
Surface water	22 ppm	.016 ppm
Well water	26.4 ppm	0 ppm
Soil		*2% Def

*2% dificiency as determined by the Sudbury soil testing kit.

It was extremely difficult to determine the effect of agriculture on the nitrogen cycles in the sites used.

Reasons:

1. Commercial fertilizers had been used for such a short period of time.
2. The total area fertilized was relatively small.

The amount of nitrogen in the water tested was relatively high.

Some problems exist in doing a study of this type on a farm with a small operation. The amounts of fertilizers being put down are so relatively small, the effect on the enviornment would in turn be very small.

If this same study were performed on a farm that fertilized hundreds of acres or had thousands of head of cattle, a greater effect on the environment could be ascertained. If the study were performed on a farm that had been using inorganic fertilizers for a long period of time the results would be different.

VI. Limitations

A friendly and cooperative farmer has to be located. Sometimes it may be difficult for an entire class to invade a farm; one can probably send the class in shifts. Clothing should be rugged and the kind that can get dirty -- one of the advantages in this kind of study is that the students are "messing" around. Parents should be aware that this is going to happen, however, so they can clothe their children accordingly.

The size of the farm will affect the kind of study undertaken. A small farm would not have the variations of practices to answer some of the questions asked. In many cases the farms of a given watershed or area would be practicing similar farming techniques so a total picture could not be undertaken.

If a choice is available, a farm that is large enough to have: a) different kinds of livestock, b) different kinds of crops (corn, clover, hay, etc.), and c) a water supply that drains the areas studied.

VII. Bibliography

1. Parameters for Detecting Pollutants with Respect to Farming

    a. American Public Health Association, Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Inc., New York City, 1971.

    b. McKee, J. E., and H. W. Wolf, Water Quality Criteria, (2nd ed.), Water Quality Control Board, Sacramento, California, 1963.

2. The Hydrologic Cycle and How It May Be Affected by Farming

    a. Bruce, J. P., and R. H. Clark, Introduction to Hydrometeorology, Pergamon Press, New York City, 1966.

    b. Thomas, H. E., The Yearbook of Agriculture, 1955: Water, U. S. Government Printing Office, Washington, D. C., 1955.

    c. Ward, R. C., Principles of Hydrology, McGraw-Hill Book Co., New York City, 1967.

3. Advanced Readings

a. Journal, Water Pollution Control Federation (3900 Wisconsin Ave., Washington, D. C. 20016)

(1) Ames *et al*, "Phosphorus Removal," May 1970.

(2) Azad and Borchardt, "Algal Growths," November 1969. Part 2.

(3) Nemerew, "Poultry Wastes," September 1969.

B. Community Survey

I. Introduction

This activity is intended to arouse the students' interest in the effects of human activities on a body of water. This is done by locating sites which might be sources of pollution; collecting samples for the necessary tests; running the tests; gathering the data; and making tentative conclusions. Then, by contacting persons associated with the community, help them to understand what their water problems are. Any level high school student can complete this activity.

II. Questions

1. Lead to the activity by asking:
    a. What are the possible sources of pollution in a body of water?
    b. What is the effect of a town's sewage and other effluents on adjacent bodies of water?
2. Initiate the activity by asking students:
    a. What are the sources of sewage and other effluents and specifically where are they located?
    b. What types of tests should be utilized?
    c. What sites are to be used in the testing process and are they representative?
3. Continue the activity with these questions:
    a. Do we have enough data to reach a conclusion?
    b. How will we use our data to arouse public interest?
    c. Should letters be sent, people interviewed, information be handed out, etc.?
4. Evaluate the activity by considering:
    a. Did the students understand the testing procedure and purpose?

b. Did the students eliminate variables that could produce errors in the data?

c. Are the students aware of the implications brought about by improper sewage and other effluent disposal practices?

d. Are the students cognizant of possible approaches that can be used to initiate public concern?

III. Equipment

1. Sterile bacteria bottles (as many as needed)
2. Sterile Millipore System (media, petri dishes, etc.)
3. Sterile bottles for making dilutions
4. DO bottles for DO, IDOD, and BOD
5. Thermometer
6. Tape recorder to record conversations of interested people

IV. Procedure

1. Field work

   a. Sites which could show the possible source of pollution should be chosen.

   b. Bacteria samples are collected.

   c. DO samples are collected and fixed immediately.

   d. IDOD samples are collected and fixed in 15 minutes. This will give an indication of the immediate dissolved oxygen demand that the micro-organisms exert on the DO content of the water.

   e. BOD samples are taken and placed in darkness for 5 days. At that time they should be fixed and titrated. This will show the total biochemical oxygen demand of the sample.

2. Lab work

   a. Prepare all materials for bacteriology in advance.

   b. Find the amount of both fecal and coliform bacteria using the standard Millipore method. Fecal is done as well as total coliform because it is an indicator of sewage in the water.

   c. Using the Winkler method, finish the DO and the IDOD tests. Then, 5 days later, do the BOD test.

   d. When all the tests have been completed, gather the data and tabulate.

V. Previous Studies

1. A group of students studied 6 sites near Wolfeboro, New Hampshire. Tests for total and coliform bacteria, DO, IDOD, and BOD were performed. The effects of the effluents on adjacent waters were studied. Data from the above studies were presented to a newsman and the influential persons in the community.

2. The article written by the newsman for the Granite State News follows:

Water Samples in Wolfeboro Prove Town is Polluting its Waterways

"Last Friday one group, and again on Monday a second group from the Tilton School Pollution Program were in the Wolfeboro Area taking water samples. The two groups, participants in the nationwide program centered at the school and financed by grants from the Ford Foundation and the Department of the Interior, were primarily interested in the general effect of human activities on a body of water. They were attracted to the Wolfeboro area by the abnormally high bacteria count in Wolfeboro Bay. In addition to this concern with water pollution, the program has two additional purposes. By forcing students and teachers into a close relationship outside the classroom, it is hoped that the program will serve a teacher training function. And, the program is also to prepare a learning guide based on the activities of the groups for use in studying pollution.

"In investigating the effects of human activity on the water supply, the groups took samples at five sites selected by Albert Powers, head of the Science Department at Brewster. The first site was on Smith River above

Wolfeboro Products, up stream from where Wolfeboro might have an effect on the water supply. The second site was by the dam at the excelsior mill in Wolfeboro Falls, the third by the sewer outlet in Back Bay, the fourth by the straw oil catch where the water from behind the shopping center flows under the railroad tracks into Back Bay, the fifth, under the bridge in the center of Wolfeboro. The sites were chosen so as to reveal any change in the condition of the water as it passed through Wolfeboro and to identify where these changes took place.

SITES TESTED

"At each site, tests were made to measure the oxygen dissolved in the water and also to measure the presence of bacteria in the water. Each group performed these tests at the sites with the Monday group acting as a check on the Friday group. The dissolved oxygen test measures the amount of oxygen in the water at the time of the test. From this, it is possible to determine what forms of life the water will support. Trout, for example, need a high amount of dissolved oxygen in order to survive.

"A second test, the immediate dissolved oxygen demand, measures how much of the oxygen is being used. If the amount being used is equal to the amount in the water then problems result because there is none left either for fish or organic breakdown.

"A third test performed measures the biochemical oxygen demand or, in other words, the amount of oxygen required by everything in the water. The absence of dissolved oxygen in addition to limiting the forms of plant and animal life also gives rise to hydrogen sulfide and methane gases. A super-saturated dissolved oxygen reading in which there is more oxygen in the water than can normally be dissolved at that specific temperature is also harmful. It appears to give rise to a higher disease rate and gill damage among fish. The tests revealed a supersaturated condition at sites two, three, and possibly four.

BACTERIA MEASURED

"Total coliform and fecal coliform counts were made to measure the bacteria present. The former indicates organic pollution such as sewage and garbage. The fecal coliform specifically measures the presence of organic matter from the intestinal tract of men and animals. Basing their conclusions on the test results and on the Recommended Use Classifications and Water Quality Standards of the New Hampshire Water Supply and Pollution Control Commission, they found that only site one was acceptable for bathing. The remaining sites would be placed in either Class C or D due to the high bacteria count. Class C is "acceptable for recreational boating, fishing, and industrial water supply" while Class D is described as "aesthetically acceptable" and "suitable for certain industrial purposes." Evidence of recent fecal pollution was found at all sites except number one. And, a significant increase in the coliform count was found between sites one and two. This would lower the quality of water from Class B to Class C. The groups found oil and grease along with other floating solids at all sites except one. Using the Commission's standards, the remaining sites would all be classified in Class C using this criteria.

"While the two groups were quick to point out that the test results were only obtained from two sets of data performed by nonprofessionals, the similarities in the two did suggest the definite presence of a serious pollution problem. The results also gave a clear-cut, qualitative proof of the effects of human activities on a body of water. The groups noted that the State empowers local governments to set up laws regarding pollution where state laws do not apply and that any local Board of Health or any 10 or more citizens could petition the water supply and pollution control commission if a public water is being contaminated."

Roger Murray

VI. Limitations

1. Before starting, be sure that all health and safety precautions are taken.
2. Before undertaking field work, obtain permission to trespass on any private properties involved.
3. A boat or float should be used in any study involving obviously polluted waters.
4. Prepared Petri dishes must be kept cool until the time of inoculation to prevent the growth of any bacteria which might have been introduced.
5. The sample must be inoculated soon after the time of collection to prevent the growth of coliforms which might have been introduced.
6. Rigorous precautions must be taken to insure the growth of only those coliforms originating within the sample.
7. Two samples should be taken from each site as a check on the validity of the results.

8. When counting colonies, respect the potential diseases within the Petri dishes.

9. One method for testing the dissolved oxygen should be selected and carried throughout the entire study to insure uniform results.

10. It should be kept in mind that the Hach kit will not measure fractional parts of dissolved oxygen.

11. When on field studies testing for IDOD and BOD, a dark cool place should be readily accessible.

12. If there is a considerable distance between the site and the equipment, chemicals to the dissolved oxygen should be brought along to prevent aeration (i.e., a steep inclination of 10 feet).

VII. Bibliography

1. Parameters of Pollution with Respect to Human Activities

    a. American Public Health Association, Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Inc., New York City, 1971. This gives a complete list of reagents, procedures, and some standards for all tests used.

    b. McKee, J. E., and H. W. Wolf, Water Quality Criteria, (2nd ed.), State Water Quality Control Board, Sacramento, California, 1963.

    c. Needham, J. G., and P. R. Needham, A Guide to the Study of Fresh Water Biology, (5th ed.), Holden-Day, San Francisco, 1962. This guide has an excellent Algal and Macroinvertebrate Key.

    d. Pelczar, Michael J., and Roger D. Reid, Microbiology, McGraw-Hill Book Co., New York City, 1965. Pages 500-512 give an excellent description of the coliform group of bacteria as indicators of possible fecal contamination. Page 513 gives a list of the effects of sewage on the environment.

    e. Renn, Charles, A Study of Water Quality, La Motte Chemical Co., Chestertown, Md., 1968. An elementary study of water and how it can be altered by unnatural (i.e., "human activities") conditions.

f. Well, R., Design, Specifications Guide, Goodwin Hydrodynamics, Inc., Weirs Beach, N. H. It contains an elementary discussion of BOD.

2. Advanced Readings

a. Journal, Water Pollution Control Federation (3900 Wisconsin Ave., Washington, D. C. 20016.)

(1) Albertson and Sherwood, "Phosphate Extraction," August 1969, Part 1.

(2) Azad and Borchardt, "Algal Growth," November 1969, Part 2.

(3) Barth et al, "Phosphorus Removal," November 1969, Part 1.

(4) Burkhead and McKinney, "Activated Sludge," April 1968.

(5) Connell and Fetch, "Handling Gas Chlorine," August 1969, Part 1.

(6) Hansen et al, "Idealized Sedimentation Theory," August 1969, Part 1.

(7) Hoover and Arnoldi, "River Pollution," February 1970, Part 2.

(8) Lighthart and Oglesby, "Bacteriology of an Activated Sludge," August 1969, Part 2.

(9) Lutge, "Submerged Effluent Collections," August 1969, Part 1.

(10) McDonnell and Hall, "Benthal Oxygen Uptake," August 1969, Part 2.

(11) Mercer et al, "Ammonia Removal," February 1970, Part 2.

(12) Moore et al, "Viruses in Waste Water," February 1970, Part 2.

(13) Nebiker et al, "Sludge Dewatering Rates," August 1969, Part 2.

(14) Tchebanoglous, "Tertiary Treatment," April 1970.

(15) Thomas and Brown, "Chlorination," April 1968.

(16) Tenney _et al_, "Sludge Conditioning," February 1970, Part 2.

ALL of the above are very detailed, complete, biochemical studies. Very specific, very informative. The texts are for the average student but are advanced for someone who is not science-oriented.

b. Sawyer, C. N., and P. L. McCarthy, _Chemistry for Sanitary Engineers_, (2nd ed.), McGraw-Hill Book Co., New York City, 1967. This is very complete and deals with advanced applications for chemistry.

C. Drinking Water

I. Introduction

1. This activity is primarily for urban schools where field work is sometimes difficult. This activity can be done completely in the classroom and the time varies between 3 and 10 class days depending on the depth of study desired. This is suitable for students on the junior or senior high school level.

2. This activity gives the students an appreciation of their drinking water supply. This is to be done by having them discover the source of their water and how it is treated to make it pure. In the end they should realize that the water they pollute is going to be used by another community like theirs, which will also have to clean it.

II. Questions

1. To lead to activity ask: Where does our drinking water come from?

2. To initiate the activity ask:
   - a. How can we find out where the water comes from?
   - b. Is there a difference between the water we drink and the water at the source?
   - c. How can the difference be accounted for?

3. To continue the activity ask:
   - a. How is the water made fit to drink?
   - b. Is there a difference between distilled water and tap water?
   - c. Is tap water the same all over the city?
   - d. How could a difference be accounted for?
   - e. What is the cost of cleaning the water?

4. To evaluate the student's performance ask:
   - a. How is our water purified?
   - b. Why is it cheaper and better not to pollute the source of our drinking water?

c. Why must some cities' water supplies be so far from the city?

d. How do you think your water system can be improved? Why hasn't it been imporved?

e. How do large rainfalls affect your system?

f. How does drought affect your water system?

g. How does pollution in your water supply affect you physically and economically?

III. Equipment

1. Introductory Level

a. Untreated samples of water from the city's drinking source

b. Maps showing the city's intake water system

c. Books and movies on water purification if it is not possible to visit a plant

d. Evaporating dishes

e. Hach or Delta kit, if available

2. Advanced Level

a. Same as above

b. Millipore equipment

c. Material for building a rudimentary model purification system

IV. Procedure

1. Introductory Level

a. Trace the city's intake pipe to its source. Discuss the importance of the location. Find out if there are any industries at the source or if it is being used as a sewage dumping ground.

b. Compare water from the tap and from the source (supplied by teacher). Have students note sensual differences between the two. Have them feel, smell, and observe color differences. Do Not Have Them Taste Water.

c. Pour water samples into evaporating dish and let evaporate. Measure the difference in the amount of suspended solids.

d. Use Hach or Delta to determine chemical differences. Suggested tests: pH, chlorine, fluoride, turbidity, iron, and manganese.

e. Draw up summary of findings. This should generate discussion which leads into the next step.

f. Present information on how your water is purified.

g. Figure the cost per person for cleaning water.

2. Advanced Level

a. Same as above but in greater detail, especially for part (d).

b. Run tests for bacteria. Refer to the bibliography.

c. Visit a filtration purification plant if possible.

d. Set up your own model purfication plant.

e. Have speakers.

f. Discover the economic soundness of cleaning polluted water for drinking versus clean water.

V. Past Studies

To a certain extent some of the parts of this activity are traditional experiments. This activity was not performed in its entirety by the writers of this publication.

VI. Limitations

Even with very little it should be possible to conduct this activity. The water from the supply can be picked up by students from different areas; several gallons will be needed. Maps, free information, and assistance can be obtained from the local water board.

VII. Bibliography and Resources

1. Books

a. Fair, Gordon Gaskew, Water and Wastewater Engineering,

John Wiley and Sons, Inc., New York City, 1966. This book gives some general description of water systems in towns and cities, but is mostly a guide to the engineering of said systems.

b. Leopold, Luna, A Primer on Water, U. S. Department of the Interior, Washington, D. C., 1966. This book gives a general description of how and why town and city water systems work.

c. Microbiological Analysis of Water, Millipore Corp., Bedford, Mass. (application report A. R. *81), 1969.

d. Millipore Experiments in Microbiology, Millipore Corp., Bedford, Mass., 1969. The above two booklets describe methods of testing water quality and bacteriology counts. Millipore equipment is used.

e. Renn, Charles E., A Study of Water Quality, LaMotte Chemical Co., Chestertown, Md., 1968. This is a brief booklet discussing water quality standards, water purification, and waste water disposal.

2. Movies

a. Pure Water and Public Health, Cast Iron Pipe Research Association. This is a good description of the purification process but use only as a last resort. It is largely selling cast iron pipes. Write to 1168 Commonwealth Ave., Boston, Mass. 02134.

b. New Water For a Thirsty World, Office of Chief Engineer, Bureau of Reclamation, Code 841, Building 67, Federal Court, Denver, Col. This is a good description of the desalination process.

D. Pollution and Recovery

I. Introduction

In this activity students will become interested in seeing the effects of a town or city on a given waterway. The fieldwork is uncomplicated, consisting of sampling the water above and below the community. The most striking results will be obtained by testing above and below a town or city that has a substantial amount of industry with little, or no waste processing equipment. Two questions should be answered in this survey: what influence does industrial waste have on the over-all environment of a waterway and what is the recovery-rate of a stream as the distance from the effluent is increased? A follow-up investigation should be undertaken to study the influence of the factors as they apply to recovery rate.

II. Questions

1. Lead the activity by asking: What effect industrial waste has on the over-all quality of this water system?
2. Initiate the activity by asking:
    a. Where should your water samples be taken in this stream?
    b. Why did you choose these locations? (This should lead to a discussion as to the desirability of collecting above, immediately below, and a considerable distance below the effluent.)
    c. Which chemical tests do you feel will prove most significant for this survey?
    d. Which tests should be done at the site, and which may be brought back to the lab?
3. Continue the activity by asking:
    a. Do you notice any prominant physical or biological changes in the immediate environment?
    b. If we came back here tomorrow and collected samples, do you think there would be a considerable variance in data?
    c. What tests, other than chemical, would prove helpful in an over-all evaluation of this stream?

4. Questions such as these may help to evaluate the efforts of the students:
    a. Did the investigation hold the interest of the majority of the students?
    b. Did they seem eager to enlarge on the subject; as to which chemicals were doing the most damage to the system, where the most pollution was coming from, what action should come next?
    c. Did all, or most, of the students enter eagerly into the task of testing the samples from the three sites? (See II 2 b)

III. Equipment

1. Other than the laboratory testing kits very little is needed to carry out this investigation. The students should be encouraged to plan most of the procedures, and collect the needed field-work equipment.
2. Sample equipment might include:
    a. Collection bottles and fixing solutions for dissolved oxygen tests (Winkler Method)
    b. Collection bottles, any size, for general samples
    c. Collection bottles for bacteria; so labeled
    d. Testing kits and equipment, (i.e., Hach, Delta, or LaMotte kits, pH testing kit, pipettes and chemicals for Winkler tests for dissolved oxygen) DO meter (for comparison with Winkler test)

IV. Procedure

1. Collect water samples from 3 locations on the river; above, immediately below, and a considerable distance below the industrial waste.
2. Take a meter reading, if possible, for dissolved O_2 at each location.
3. Fix the oxygen in one bottle from each location with solutions of manganese sulfate, and alkali-iodide-azide. (For Winkler test--dissolved oxygen.)
4. Collect bacteria samples from each location.

5. Return to lab and make tests.

V. Previous Studies

1. Previous studies of this investigation have pointed out to the students which dissolved solids are most closely allied with industrial waste.

2. Some students are surprised that a stream that shows a high degree of pollution just below an effluent shows a remarkable degree of recovery over a comparatively short distance.

3. It has been noted that with most students there is a great desire to investigate the cause of each pollutant, and to work toward finding ways to eliminate the source. This investigation stimulates interest in over-all "ecotactics."

VI. Limitations

Other than the bacteria cultures, which are demanding, very few factors can hinder significant results from this investigation. Extreme accuracy is not important, as the comparison between above and below samples is very conclusive. Transportation to collection sites is the only real concern. Suitable clothing should be worn. Hands should be thoroughly cleaned after collecting heavily polluted water.

VII. Bibliography

Klein, L., River Pollution 3 Control, Butterworth & Co., London, England, 1966. It gives very complete coverage of total river pollution problems and is an advanced text.

Mackenthum, K. M., The Practice of Water Pollution Biology, Department of the Interior, Washington, D. C., 1969. This may be of some use for sampling techniques. It has little to offer over the testing kits.

McKee, J. E., and H. W. Wolf, Water Quality Criteria, State Water Quality Control Board, Sacramento, Calif., 1963. This is a very complete compilation of standards for all industrial and household uses of water. Standards for most stages are listed according to water usage.

Ruttner, F., Fundamentals of Liminology, University of Toronto Press, Toronto, Canada, 1969. Pages 56 to 104 cover all dissolved solids found in fresh water but is quite involved for the beginning student.

U. S. Department of the Interior, Pollution Control Administration, Biological Field Investigation Data for Water Pollution Surveys, U. S. Government Printing Office, Washington, D. C. This is a very fine booklet for general use on water pollution and costs only seventy cents. It has a very complete list of ecologic terminology and good chemical tables, especially on dilution.

E. Destructive Effects of Water Pollution

I. Introduction

The activity, which has a field and lab procedure, shows the effects of water pollution on concrete or any other materials. Eighth-grade students and above can relate certain human activities, causing water pollution, to the deterioration of materials stationed in the water. If a situation cannot be found where pollution is causing deterioration, this may be simulated in the lab.

II. Questions

1. To lead to the activity determine if there is a body of water in your area affected by human activities, and then inquire:
   a. Does the water have any effect on materials with which it comes in contact?
   b. What are some of the human activities in the area that would cause pollution?
2. Initiate the activity by asking:
   a. How would you determine the cause of the problem?
   b. How could you find results and interpret them?
3. Continue the activity with:
   a. Can you fit the interpretations into legislative action?
   b. How can you set up a controlled laboratory experiment to simulate the problem? (bioassay)
4. Evaluate the activity by determining:
   a. Did the students use a systematic approach to find and solve the problem?
   b. Did the students attempt to make any conclusions from the tests run?
   c. Can the student verify his observations?

III. Equipment

1. Field equipment (depends on the size of the body of water and whether it is a lake, stream, or river)

   a. Dissolved solids testing equipment
   b. Collecting 3 - 6 bottles of 1 liter capacity
   c. Water gear (boots, boats, work clothes, bug spray)
   d. Photographic equipment (optional)
   e. Flow equipment (stop watch, orange, meter stick, 25 meter measuring tape)
   f. Maps, data sheets

2. Bioassay materials
   a. Samples of materials (cement, wood, aluminum boats, iron, steel)
   b. Chemicals affecting materials (sulfurous acids, alkali, oils, synergism of chemicals)
   c. Distilled water

IV. Procedure

1. Field procedure
   a. Find a material that is being affected by water problems.
   b. Determine factors that cause material deterioration. A few of these are: natural erosion; corrosion, industrial wastes and algae (see bibliography).
   c. Collect equipment.
   d. Take water samples at representative sites.
   e. Test samples to see if factors determined in procedure "b" are present.
   f. If possible, study the human activities along the stream to gain knowledge of effluents added to the water.

2. Lab procedure (if stream and pollution problem is not available)
   a. Determine factors that cause materials to deteriorate.
   b. Set up controlled experiments to show how the factors affect the materials.

c. Draw conclusions.

V. Limitations

1. Field procedure requires affected area for study.
2. Much time and transportation is needed for testing and sampling.
3. Lab experiments could also take much time. Note: The more concentrated the chemicals the quicker the results.
4. Test knowledge of the dissolved solids.

VI. Past Studies

Participants in a Water Pollution study course at Tilton School, July 1970, made a study of the Daniel Webster Memorial Bridge in Franklin, N.H., which was affected by cement corrosion. They also hoped to make an accurate report to the Franklin city officials. The corrosion could have been blamed on many factors. It could be natural; it may have been caused by chemicals dumped from industries on the side of the river; it may have been caused by dumping of snow (plus salt and sand) over the bridge onto the cement foundation, during the winter. The tests consisted of DO hydrogen sulfide, carbon dioxide, pH, alkalinity, sulfates, copper, nitrates and phosphates. They were taken at areas that would show if any chemicals were added to the river; such as above and below the entrance of possible effluents. After gathering results, interpretations were made. Research of chemicals that corrode concrete was made and compared to results. The chemicals and their effects are outlined below:

1. Corrosive factors that affect concrete:
    a. Water mixed to make concrete should be suitable to drink (free from acids, alkalies, and oils).
    b. Rate of flow of stream affects corrosion; density of cement is a factor in corrosion.
    c. Other factors of corrosion:
        (1) Creosote, cresol, phenol, and many vegetable and animal oils.
        (2) Sulfates.
            a. Sodium.
            b. Magnesium.

(3) Sulfurous acids (SO_2) over 25 ppm.

(4) CO_2 greater than 20 ppm.

(5) Water with greater than 100 ppm of carbonate hardness if water has low temperature and is constantly reviewed.

(6) Sewage in waters of low pH and high temperature favors high H_2S which oxidizes into sulfates. Synergism between CO_2 and sulfates.

2. By-products of copper electrolite industry:
   a. Copper smelting,
   b. Waste heat through cooling waters,
   c. Waters with added sulfates and sulfuric acids.
3. Electroplating:
   a. Use of alkaline solutions and acids,
   b. Use of demineralized water for rinsing.
4. Tanning:
   a. Needs low concentrations of free CO_2,
   b. Needs low concentration of bicarbonate.

VII. Bibliography

McKee, J. E., and H. W. Wolf, Water Quality Criteria, State Water Quality Control Board, Sacramento, Calif., 1963. "Quality Criteria for the Major Beneficial Uses of Water," pages 88 to 96, discuss concrete corrosion. Also in this same chapter, there are explanations of industries that could dump effluents that are destructive: page 98 for the copper industry; page 99 for electroplating and metal finishing; and page 106 for the tanning industry.

F. Sewage Treatment

I. Introduction

In this activity students learn about sewage and waste treatment. The students learn how sewage is processed in their town and in neighboring communities. New laboratory techniques and equipment will be introduced which will enable students to determine the efficiency of various sewage treatment procedures and to appreciate, in a more precise way, the problems involved in an important but often neglected or unnoticed part of everyone's life. The time required may vary from two to four periods or longer depending on the difficulty of selective procedure, student interest, and time and equipment available. The activity is designed for students from 7th grade and up.

II. Questions

1. To lead the activity ask: What happens to the sewage and waste waters in your community after leaving their point of origin?
2. To initiate the activity ask:
    a. What type (primary, secondary, tertiary) or waste treatment facilities does your community have? (Consult local authorities, i.e., local health departments and sanitary engineers.)
    b. Are all types of wastes (sewage, runoff) treated in the same way?
    c. How effective is this treatment?
    d. Could it be improved? How?
3. To continue the activity ask:
    a. Are the methods of elimination of pollutants which you have encountered the most effective methods possible?
    b. If not, why not?
    c. What tests can be performed to determine the effectiveness of treatment plants?
4. To evaluate the student's performance ask:
    a. Do you consider the sewage treatment in your community adequate?

   b. What can we as individuals or members of groups do to help improve sewage treatment methods?

III. Equipment

1. Introductory Level
    - a. Sample bottles
    - b. Microscope
    - c. Hach or Delta kit
    - d. Aquatic identification books for identifying microorganisms
2. Advanced Level
    - a. Same as above
    - b. Millipore equipment or standard bacteriological materials
    - c. Titration equipment for Winkler, BOD
    - d. Materials for constructing a model treatment system

IV. Procedures

1. Introductory level
    - a. Using microscopes and identification books identify the organisms found in samples.
    - b. Using the Hach or Delta kit determine the level of nitrates in the water. Determine why this level is so important.
    - c. Draw diagrams of the local treatment plant.
    - d. Determine pH. Why is it important in processing sewage?
2. Advanced Level
    - a. Same as above
    - b. Using the Hach and Delta, determine the levels for dissolved solids you feel are important in sewage treatment based on what you have learned, in preparing for this activity and your study of the treatment plant.

c. Using Millipore filter technique, or other methods, determine the level of bacteria before and after treatment. Also determine why this level is important.

d. Determine how bacteria are used in sewage treatment. (Discussion)

e. Determine the level of DO, IDOD, BOD in water before and after treatment, and in the body of water into which the treated sewage is dumped. Discuss the significance of the results (refer to Standard Methods for technique).

f. Build a model sewage treatment plant.

V. Past Studies

1. A group of students from Quincy, Mass., found their bay to be suffering from rapid biological aging (eutrophication). Also, it was being polluted by "storm" drains from a combination storm-sewage system. They studied the advantages and disadvantages of secondary treatment, the dangers of daily chlorination, and the problems of algae.

2. Another group of students from Quincy made a study of the effects of sludge being pumped into the bay at a rate of 2 million gallons a day. They concern themselves with BOD, eutrophication and floating solids.

VI. Limitations

If there is no treatment plant in your area it will be necessary to take field trips. Movies and books may have to replace the primary learning and experience of visiting the plant. Supplemental equipment may consist of: paper chromatography; standard analytic procedures, quantitative and qualitative analyses, etc.

VII. Bibliography

1. Introduction to Sewage Treatment.

a. Pelczar, Michael J., and Roger D. Reid, Microbiology, McGraw-Hill Book Co., New York City, 1965. This is an excellent source for an outline of sewage treatment. Pages 511-522 discuss the biological and chemical characteristics of sewage and outline Primary and Secondary Treatment.

b. Renn, Charles, A Study of Water Quality, LaMotte Chemicals Co., Chestertown, Md., 1968. An elementary discussion of water quality and how it can be altered by unnatural conditions. It is presented along with good background materials and good references.

c. U. S. Department of Health, Education, and Welfare, "Municipal Sewage Treatment Process," No. 002599. This is a good film for teacher and student, leading into and initiating the activity; it is black and white and slightly outdated.

2. Parameters of Sewage

a. American Public Health Association, Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Inc., New York City, 1971. This is a complete set of directions, from making reagents to performing tests. It is a good reference but is quite complicated.

b. Pelczar, Michael J. and Roger D. Reid, Microbiology, McGraw-Hill Book Co., New York City, 1965. Pages 500-504 contain an excellent discussion of the coliform group as indicators of pollution. It is very complete and can be understood by the "average" junior high student. Page 513 gives a list of the effects of sewage on the environment.

c. "A New Prospect," Environment, Vol. 12, No. 2, March 1970. This is a study of the parameters of sewage and problems of sewage on the environment. It is a good study of the effects of sewage on the environment.

3. Advanced Readings

a. Journal, Water Pollution Control Federation (3900 Wisconsin Avenue, Washington, D. C. 20016)

(1) Albertson and Sherwood, "Phosphate Extraction," August 1969, Part 1.

(2) Azad and Borchardt, "Algal Growth," November 1969, Part 2.

(3) Barth et al, "Phosphorus Removal," November 1969, Part 1.

(4) Burkhead and McKinney, "Activated Sludge," April 1968.

(5) Connell and Fetch, "Handling Gas Chlorine," August 1969, Part 1.

(6) Hansen *et al*, "Idealized Sedimentation Theory," August 1969, Part 1.

(7) Hoover and Arnoldi, "River Pollution," February 1970, Part 2.

(8) Lighthart and Oglesby, "Bacteriology of an Activated Sludge," August 1969, Part 2.

(9) Lutge, "Submerged Effluent Collections," August 1969, Part 1.

(10) McDonnell and Hall, "Benthal Oxygen Uptake," August 1969, Part 2.

(11) Mercer *et al*, "Ammonia Removal," February 1970, Part 2.

(12) Moore *et al*, "Viruses in Wastewater," February 1970, Part 2.

(13) Nebiker *et al*, "Sludge Dewatering Rates," August 1969, Part 2.

(14) Tchebanoglous, "Tertiary Treatment," April 1970.

(15) Thomas and Brown, "Chlorination," April 1968.

(16) Tenney *et al*, "Sludge Conditioning," February 1970, Part 2.

(17) Zablatsky and Petterson, "Anaerobic Digestion Failures," April 1968.

All are very detailed, complete, biochemical studies, not for the average student or someone who is not science-oriented.

b. Sawyer, C. N., and P. L. McCarthy, *Chemistry for Sanitary Engineers*, (2nd ed.), McGraw-Hill, New York City, 1967.

G. Biochemical Oxygen Demand In Sewage

I. Introduction

The BOD test, Biochemical Oxygen Demand, is designed to determine the amount of oxygen bacteria required to break down sewage. There are 3 factors in the breakdown of sewage which require oxygen: (a) carbonaceous organic material usable as a food by aerobic organisms; (b) oxidizable nitrogen and organic nitrogen compounds which serve as food for specific bacteria, and (c) certain chemical reducing compounds which will react with molecularly dissolved oxygen. There is an incubation period of 5 days in which the 3 factors above are given time to use oxygen. Therefore, for one to incorporate this activity into the classroom, one must make time for collection of samples, seeding, and after incubation, the BOD test. The activity may be designed to fit almost any age group. It is a good activity with which to teach lab techniques for 10th graders and older students.

II. Questions

1. To lead to the activity ask:
    a. What causes the breakdown of wastes?
    b. What must be present for this breakdown to occur?
    c. Would it be possible that there may not be enough of this substance to complete this breakdown of the waste?
2. To initiate the activity ask: How shall we test for this substance and find out if a BOD exists?
3. To continue the activity tell the students the procedure for the BOD test and let them continue with testing of sites of their own choice. Because of the complexity of this procedure, the teacher must answer the students' questions directly.
4. To evaluate the students' actions observe who participates, how much work each individual does, and how well they do the work. Also watch the organization the students build up on their own.

III. Equipment

1. 500 ml. sample bottles
2. 300 ml. sample bottles
3. Some standard method of determining DO

4. Pipettes
5. Graduated cylinders
6. Beakers
7. Heavy brown paper
8. Tape and marking pencil

IV. Procedure

The procedure given here is very sketchy. For more detail, refer to Standard Methods.

1. Prepare organic-free dilution water. Distilled water may be used.

2. Determine the DO content of the dilution water.

3. Determine the DO content of the waste water to be tested.

4. Make several dilutions of the prepared sample so as to obtain the required depletions. The following dilutions are suggested: 99.9 to 99.0% for strong trade wastes, 99 to 95% for raw and settled sewage, 75 to 95% for oxidized effluents, and 75% to no dilution for polluted river waters. The dilution of the samples is called seeding. For example, a 95% dilution indicates 5 ml. of sample plus 95% sterilized distilled water.

5. Put an airtight seal on the bottles and store in a dark place for 5 days at a temperature of 68 degrees F (20 degrees C).

6. During the incubation period, calculate the initial DO content of the incubated sample. Below is the equation for calculating the initial DO, (d) content of the incubated sample.

$\frac{(x)}{(y)} X(d) = \text{ppm}$ DO contributed by waste water

x is the amount of the sample used to make up the incubated sample.

y is the total volume of the incubated sample.

d is the DO content of the waste water.

$$\left(\frac{z}{y}\right)X(D) = \frac{\text{ppm}}{\text{ppm}} \quad \begin{array}{l}\text{DO contributed by dilution water}\\ \text{DO Total DO initially}\end{array}$$

z is the amount of dilution water used in the incubated sample.

D is the DO content of the dilution water.

7. After 5 days, determine the DO content of the waste water-dilution mixture.

8. On the basis of oxygen depletion and the relative proportions of waste water and dilution water, calculate the oxygen demand of the organic material in the waste water.

$$\left(\frac{y}{x}\right)X(I - H) = \text{ppm of oxygen demand or BOD}$$

I is the total DO initially.

H is the DO of the sample after incubation.

V. Limitations

The greatest limitation of the BOD test for classroom application, is the fact that the procedure runs into much technicality. However, with some modification, the test may be fitted to younger age groups. It would be wise to be well-informed before proceeding. One must also have fairly reliable equipment in order to procure accurate data. At least a half a day should be allotted for completing the sample collecting and preliminary testing before incubation.

VI. Past Studies

1. A group of students concerned themselves with setting parameters of sewage influent-effluent flow, concentrating on the ability of secondary treatment to remove oxygen-demanding materials from sludge.

2. A team of students attempted to isolate the three classes (Standard Methods) of oxygen-demanding materials.

VII. Bibliography

1. Introductory Literature

a. Pelczar, Michael J., and Roger D. Reid, Microbiology, McGraw-Hill Book Co., New York City, 1965. It gives an excellent operational definition of BOD on page 512.

b. Wells, R., Design, Specifications Guide, Goodwin Hydrodynamics, Weirs Beach, N. H. This is a good elementary procedure for preparing and performing BOD.

2. Advanced Reading

American Public Health Association, Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Inc., New York City, 1971. This gives complete information on seed dilution factors, etc. This is not a good reference for the average student.

H. Effect of Oil on Aquatic Life in Recreational Waters

I. Introduction

The Water Quality Act of 1965 states the following: "Standards of quality.....shall be such as to protect the public health or welfare, enhance the quality of water and serve the purpose of this act." Included among substances banned from recreational waters are floating debris, oil, scum, and other matter. This study regards fuel oil discharged by small craft on recreational waters as hazardous. Concentrations higher than 50 gal. per $mi.^2$ may coat the bodies of bathers causing skin irritation. This oil sometimes blocks sunlight, thus preventing photosynthesis in aquatic plants at the bottom of the body of water. It can also stick to the gills of fish and interfere with their respiration. It may also coat the bottom of the body of water, endangering spawning areas. 9th graders and above may do this activity.

II. Questions

1. To lead to the activity ask:
    - a. How does oil on the surface of recreational waters affect aquatic life?
    - b. How could a student test the effect of fuel oil on a certain type of aquatic life?
    - c. In testing to find this effect, which would be more advisable to use, plants or animals?
    - d. How would you collect the living specimens that you would like to use?
    - e. What do you think that you would need to perform this experiment?
2. To determine the quantitative relationship of oil concentration to the surface color, ask:
    - a. What is an oil slick?
    - b. At what concentration of oil does the slick become visible?
    - c. At what concentration is an oil slick seen as a silvery sheen on the surface of the water?
    - d. At what concentration of oil are bright bands of color visible?

3. To evaluate this experiment ask:
    a. Why did you use a control during the experiment?
    b. Was timing accurate during this work?
    c. Were all of the organisms used during this project of the same species, size, etc., and do you think that any variations in these could have changed the effects of this experiment?

III. Equipment

1. Net
2. Container in which to place organisms that are caught
3. Tank in lab to keep organisms in water from natural habitat
4. Beakers
5. Graduated cylinders
6. Pipettes
7. Watch with a good second hand
8. Oil (inexpensive)

IV. Procedure

1. Make field trips to observe oil on lakes and streams.
2. Complete the following to see the effect on fish.
    a. Add 10 ml. water to beaker #1, 50 ml. to #2, 100 ml. to #3, 150 ml. to #4, and 150 ml. to #5 (control).
    b. Add 3 ml. of fuel oil to each beaker except control.
    c. Note time of addition of oil and time of death of fish.
    d. Record data carefully.

V. Previous Studies

1. Chipman and Galtsoff (1949) showed that low concentrations of oil are toxic to fresh-water fish.
2. Pickering and Henderson (1956) made toxicity studies of oil on minnows.

VI. Limitations

1. Be sure to have a small fish net because it is difficult to remove a small fish from the tank.
2. Make sure that the smallest amount of water (in this case, 10 ml.) is enough to support the size fish you are using.

VII. Bibliography

1. FWPCA, Report of the Committee on Water Quality Criteria, U. S. Department of the Interior, April 1, 1968. We found references to previous studies made on this topic.

2. FWPCA, Water Quality Studies: Clean Water, Training Manual, U. S. Department of the Interior, October 1969. It contains good references to the effect of oil on the surface of water.

3. McKee, Jack E., and Howard W. Wolf (eds.), Water Quality Criteria, State Water Quality Control Board, Calif., 1963. This book contains good references to fuel oil.

Human Activities

I. The Effects of Damming or Impounding Water

I. Introduction

This investigation was devised to determine the long-range effects a dam has on river and the difference in the present-day condition of the river above and below the dam. 8th graders and older students with a background in the various water pollution tests may complete this activity.

II. Questions

1. Lead to the activity by asking:
    a. What biotic and abiotic factors are involved in a stream's equilibrium?
    b. How would a dam interfere with these factors? Specifically, which factors would be altered?
2. Initiate the activity with:
    a. How would you measure the changes caused by the dam?
    b. What tests might be performed to measure such changes?
3. Continue the activity with:
    a. What are the interrelationships between abiotic and biotic factors?
    b. How would different dams effect different purposes, for example, a recreation dam as opposed to one used for flood control? Would a dam used to generate electricity by hydroelectric power produce problems different from those created by a steam-generating plant located at the dam?
4. To evaluate the activity:
    a. How did the student solve problems which arose from the physical characteristics of the site (depth of stream too great to be measured without a raft, the problems of gaining access to a dam, etc.)?
    b. What have the students found to be the advantages and disadvantages of impounding water?
    c. Has the student gained an understanding of the term "watershed"? Can he outline the watershed of this river? Can he predict the effects of an unusual condition which might occur upstream?

d. Can the student offer explanations for differences he noted up and down stream from the dam?

e. Does the student feel he has gained an understanding of the problems involved in the planning and maintenance of such a body of water?

III. Equipment

1. Hach kit, Delta-50 kit or LaMotte kit
2. Dissolved oxygen meter
3. Secchi disk for measurement of turbidity
4. Meter stick
5. Rope or chain
6. Styrofoam ball or orange
7. Watch with second hand or stop watch
8. Thermometer
9. Life raft perhaps
10. Core sampler
11. Kemmerer sampler for collection of water at great depths

IV. Procedure

1. Selection of a site

The site should be employed only after some investigation. One must determine whether or not access to the dam can be gained. The best way of locating a site may be to check the map, and then to be in touch with the personnel at the dam so that selection of site will be made easy.

2. Short range versus long range procedures

Rather than simply performing the tests once, one might perform them over a succession of days or months. In addition one might find statistics from previous studies of the area and compare these to the data one has collected.

3. Actual testing

Turbidity, dissolved oxygen, carbon dioxide, pH, and temperature may be determined above and below the dam.

Tests for rate of flow might be performed. Additional studies of settling rates of suspended particles, the contents of a core sample, and various tests of deep water samples may be carried out.

4. Correlation

Comparison graphs of biotic and abiotic factors might be made from these conclusions on the dam's effect on the abiotic and biotic factors. It is wise to be in touch with the State Health Department, for it is from them that previous data may be obtained.

V. Previous Studies

1. A group of students studied a dam and the river at sites above and below the dam. They were amazed at the effect of impounding the water on the surrounding community.

2. Another group studied a flood-control dam which was also used for recreation. It was interesting to determine whether both could be done simultaneously and still effectively.

3. A group was interested in the trees of the area surrounding the dam and suggested further study.

4. Still another group in its study, attempted to determine whether siltation occurred and what its long range effects might be.

5. In one study, students discovered that the installation of a sewage treatment plant, several miles above the dam site produced startling results in the bacteria dnd dissolved oxygen counts. (Further investigations as an outgrowth of this situation, in the classroom).

VI. Limitations

1. Short-range Study

a. Access to the desired site cannot be assured due to the abutments in the structure of a dam. Thus, the student must bring a long rope with which to suspend a bucket, thermometer, etc., to test the water. In such cases, the core and Kemmerer Samplers are helpful.

b. The Kemmerer Sampler presents many problems. A chain must be used to suspend the sampler. One must make sure this chain is straight, in order that the "messenger" can slide freely down it. In hauling up or letting down the chain, the hands may be hurt by friction caused. To prevent this, a winch or rubber gloves should be brought along.

c. Below the dam, at your site, make sure the water is not so turbulent as to prevent access.

d. In getting rate of flow, make sure your raft is far enough removed from the generator's intake valves so that it is not affected by the undercurrent (i.e., sucked in)

e. Suggestion: If your dam is used for the production of electricity, take a tour of the plant if at all possible. It is interesting.

2. Long-range Study

a. One note may be made here and that is that water pollution surveys do not date back to before the 1940's in most cases. Because of this, the dam on which the study is performed must be relatively young.

b. Suggestion: If at all possible make a comparison between the bottom topography of the stream before and after the dam was built.

VII. Bibliography

1. Benton, A. H. and W. E. Werner, Jr., Field Biology and Ecology, McGraw-Hill Book Co., New York City, 1965.

2. Billings, W. D., Plants, Man and the Ecosystem, Wadsworth Publishing Co., Belmont, Calif., 1970.

3. Kormondy, E. J., Concepts of Ecology, Prentice Hall Biological Series, T. H., Inc., Englewood Cliffs, N. J., 1969.

4. Life Science Library, Ecology, Time, Inc., New York City, 1969.

5. Odum, E. P., Fundamentals of Ecology, (2nd ed.), W. B. Saunders Co., Philadelphia, Pa., 1971.

J. Community Water Supplies

I. Introduction

In this activity it is presumed that the student has an understanding of the amount of water needed or used by urban centers. From this point he will proceed to discover from where this water comes and what steps are taken to protect the water supply. Several other avenues are opened as possible future activities depending on the interest of the student. This activity may be carried out by 6th through 12th graders.

II. Questions

1. To lead to the activity ask:

   Where does your water come from?

2. To initiate the activity ask:

   What is the watershed of the water supply?

3. To continue the activity ask:

   (At this point several paths are opened which might be followed to advantage)

   a. What are the controls on the human activities within the watershed? What are the provisions of enforcement of these controls?

   b. If an impoundment exists, what have been the effects downstream from the dam?

   c. Has the evaporation of impounded water caused detrimental concentrations of dissolved solids? Are any impounded supplies faced with this problem?

   d. Evaluate the effectiveness of the controls placed on the watershed by comparing the water runoff with that of an equal-sized region which is not controlled.

   e. If supply is a flowing river, what controls are placed upon the upstream facilities such as cities, industries, etc. What are state controls on effluents? If the river is an interstate one, how do state controls compare?

   f. How does the seasonal variation in the river flow affect the concentration of contaminants?

g. If the supply is a deep well, try to trace the underground flow by reference to geologic factors. For instance, much of the deep water in midwestern plains states originates in the Rocky Mountains. How does this long path affect the water quality and flow?

4. To evaluate the student's performance have him describe the water sources of his urban community and give the factors which he feels are important to its preservation.

III. Procedure

1. Contact should be made with the public water supply department to obtain a map showing the water supply or supplies of the urban center. The supplies may be surface entrapment, deep well, or flowing river.

2. If the supplies come from a deep well source, a geologic map showing underground structures and sand-bearing strata would be needed. If impounded, a topographic map would be needed and the region contributing water to the impoundment would be outlined. (This assumes a knowledge of map reading.)

3. If the source is a flowing river, a topographic map of large area coverage would be required and the watershed outlined. The towns, cities, and industries in this watershed should be designated.

IV. Equipment

1. Appropriate maps

2. Contacts with state and city departments responsible for public water supply

V. Past Studies

To date, no known past studies on a secondary level have included a thorough investigation of the sources and methods of protection for a municipal water supply.

VI. Bibliography

1. McKee, J. E., and H. W. Wolf, Water Quality Criteria, (2nd ed.), State Water Quality Control Board, Sacramento, Calif., 1963. This is a good reference on the major uses of water, including domestic water supply.

2. U. S. Department of the Interior, A Primer on Water, U. S. Government Printing Office, Washington, D. C., 1960. This simplified pamphlet (good for 6th to 12th grade use) explains hydrology and water use, including city water systems.

K. Investigating Lead Concentrations in Automobile Exhausts

I. Introduction

In this activity lead concentrations of car exhausts will be investigated. This project is an outgrowth of water pollution investigations. It was a natural development which takes advantage of procedures common to water pollution work. One of the intentions of this activity was to make a springboard from which other types of lead concentration-investigations could be devised.

II. Questions

1. which lead to the activity:
    a. Why are large amounts of lead in the air a problem?
    b. Where does most of this lead come from?
    c. What is lead used for in gasoline?
2. which initiate the activity:
    a. Would different types of cars give off differing amounts of lead?
    b. Would the type of gasoline used determine in any way the amount of lead given off?
    c. What types of gasoline give off the most lead?
3. which continue the activity:

    How do the lead concentrations given off by automobiles compare with the amounts given off by other internal combustion powered machines (i. e., buses, trucks, motorcycles, lawnmowers)?
4. which evaluate the activity:
    a. How do the data collected in this activity compare with other studies in this area?
    b. What interfering factors and built-in errors might there be in this method of testing?

III. Equipment

1. This activity uses a hydrid Hach-Millipore procedure. Millipore air pollution equipment is used for detecting

the lead and then the Hach colorimeter is used to give quantitative results. Standard Millipore air-testing equipment including filters, number AAWG04700 and pads number HAWG04750.

2. Tetrahydroxy - p-benziquinone (THQ)
3. Isopropanol
4. Acetone

IV. Procedure

1. Make up standard solutions of lead nitrate to be used to calibrate the metering system.
2. Draw solutions through filters, solubilize these in 25 ml. of acetone and read on the colorimeter.
3. Make up indicator solution of tetrahydroxy quinone by dissolving an excess amount of tetrahydroxy - p-benziquinone in 10 ml. of isopropanol, filter, and then through this filter pour 10 ml. of distilled water to produce the workable 20 ml. solution.
4. Place 2 ml. of this solution on a pad in a Petri dish.
5. To collect sample place a filter in the sterifill system and place over the exhaust pipe. A limiting orifice should be used in the connection to the vacuum source. The sample should be collected for a standard amount of time.
6. Place the filter on the THQ-soaked pad, face up, and allow 30 seconds for the purplish color to develop.
7. After 30 seconds place the filter in a colorimeter bottle containing 25 ml. of acetone and shake vigorously to dissolve the pad.
8. Read the sample in the colorimeter on scale Number 2667 using filter Number 2408. The colorimeter should be calibrated with colorimeter bottle of pure acetone.
9. Compare to standards to get milligrams of lead per liter of exhaust.

V. Past Studies

The author developed this test from Millipore's qualitative procedure for determining the presence of lead. Lead nitrate solutions ranging from .01 to .1 grams of lead nitrate were made up. Because of a lack of time not enough were made up to make as accurate a test as would be desired. Therefore, it is hoped that participants will make their own scaling system. To do this, many standards were made up and pulled through filters and then measured in the standard way. The results were then graphed and a formula was devised to give a result. This formula is:

$$-0.004 \times \text{meter reading} + 0.339 = \text{lead nitrate.}$$

However, this only gives the number of equivalent grams of lead nitrate in the whole sample. A workable number was desired. Therefore, the number gotten by the formula was multiplied by .6 which is the amount (by mass) of lead nitrate that is lead. In this study, a 14 liters-per-minute limiting orifice was used and samples were taken for one minute. The answer from above, then, would be the number of grams (or milligrams) of lead in 14 liters of exhaust. The answer was then standardized to one liter by dividing by 14. To summarize, the method of obtaining a quantitative result was to use this formula:

$$\text{lead nitrate} \times .6/14 = \text{mg. of lead per liter.}$$

The tetrahydroxy - p-benziquinone is quite expensive. It was found that very little was wasted if the filtrate was reused. No noticeable loss in accuracy was observed. The indicator solution was found to go bad quite quickly, sometimes in as little as a few hours. This is the reason for mixing in such small quantities. The color produced by the lead also fades quickly.

VI. Limitations

The main limitation of this test is the questionable accuracy thereof. However, more work in this area could alleviate this problem. Other limitations are: the expense of the chemicals and equipment; the expediency with which the test must be done to preserve accuracy, and the safety factor which must be kept in mind while working near exhaust pipes.

Chapter 3 Ecological Perspectives

To understand the effects of pollution, one should study organisms and determine their relationship to the nonliving part of the environment in which they live. An ecological perspective results when these relationships are understood as they affect the quality of the abiotic environment.

Previous studies[1] indicate that a single group of organisms (with the exception of coliform bacteria) is not reliable as an indication of water quality. Only a total biotic study reveals the true quality of a body of water.

The activities presented in this section employ techniques of bacteriology, aquatic biology, chemistry, geology, physics, and engineering to delve into aquatic ecosystems. The following fundamental questions dealing with a given aquatic system outline the scope of this chapter.

1. How many kinds of organisms are present? What else is present?
2. What is the diversity index above and below an effluent on a given stream or around the shoreline of a given lake?
3. What is the relationship between any two of the following to the diversity index of a waterway:

   suspended solids
   flow
   type of bottom
   dissolved solids--phosphate, nitrate, sulfate, chloride
   iron copper
   dissolved gases--oxygen, carbon dioxide, methane
   hydrogen sulfide

4. What is the effect of varying concentrations of dissolved materials such as Cl or phosphate on the species population or diversity index of a microcosm?
5. Does the diversity index change as one goes downstream?
6. What are the species populations of an aquatic system? What is the biomass and/or energy flow in a particular system?

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[1] U.S. Department of the Interior, Biological Field Investigative Data for Water Pollution Surveys (Washington, D.C.: U.S. Government Printing Office), p.4.

7. Do the concentrations of dissolved oxygen and carbon dioxide change over a 24-hour cycle? Does the diversity index of an aquatic system change over a 12-month period?

The following resources will be found useful throughout the chapter. A bibliography is listed at the close of each activity.

American Public Health Association, Standard Methods for the Examination of Water and Wastewater, (13th ed.), American Public Health Association, Inc., New York City, 1971. This book discusses biological collection techniques, bioassays, and chemical analysis and contains good drawings of the organisms. Every school should have at least one of these.

Hedgepeth, J. W., Treatise on Marine Ecology and Paleocology, Memois 67, Geological Society of America, 1963. This is a good reference for marine studies. Chapter 4, "Obtaining Ecological Data in the Sea," is particularly useful.

Needham, J. G., and P. R. Needham, A Guide to the Study of Fresh Water Biology, Holden-Day, Inc., San Francisco, Calif., 1962. This guide contains excellent drawings of organisms and is easily carried into the field.

Usinger, R. L., Aquatic Insects of California, University of California Press, Berkeley, 1956. This can be used for most locations within the United States.

Welch, P. S., Limnological Methods, Blakiston Co., Philadelphia, Pa., 1968. This is highly recommended.

Wilhm, J. L., "Patterns of Numerical Abundance of Populations," The American Biology Teacher, March 1969, pp. 147-150. A diversity index is presented as well as other means of statistically analyzing biological data.

Ecological Perspectives

A. Aquatic System

I. Introduction

The purpose of this investigation is to involve students in studying a total aquatic system. This activity would be carried out to begin the study of Ecological Perspectives. Most of these activities would take place at the secondary level; however with proper teacher adaptation, some could be used at elementary levels. The basic and advanced levels differ mostly in the accuracy and, therefore, the expense of the equipment involved.

II. Questions

1. To lead to the activity ask:

   How many kinds of plants, animals, and microbes are present in this aquatic system?

2. Initiate the activity by posing:

   How are you going to collect these?

3. Continue the activity with:

   What are the physical characteristics of the system?

4. Evaluate the performance of the students by considering questions such as:

   a. How many species were present in the student's samples?

   b. How many did the students find?

   c. Were the samples representative?

   d. What are the pertinent physical characteristics?

   e. Did the students study them?

   f. How well did the students work (as opposed to hacking)?

   g. What seemed to interest them most?

   h. Were the students able to fit all the parts together and form an understanding of the whole system?

III. Equipment

(The Equipment and Procedure sections are suggestions only. Teachers should encourage their students to develop equipment and procedures of their own.)

1. Basic Level
    a. Several thicknesses of cloth to filer out microbes
    b. Some screen to collect bottom dwelling organisms
    c. Container for collected plants
    d. A float for estimating stream flow
    e. A can for collecting bottom sediment or gravel
    f. A microscope
2. Advanced Level
    a. A plankton net or membrane filter apparatus
    b. A Surber Sampler or Ekman Dredge (you can make your own quantitative samplers)
    c. Containers and keys for collected plants
    d. A stream flow meter or a watch with a second hand, a meter stick, and a float
    e. Core sampler, Ekman Dredge, or Kemmerer Sampler
    f. A microscope for counting cells such as Sedgwick-Rafter, Palmer, or haemocytometer

IV. Procedure

1. Basic Level
    a. Pour sample water through cloth and study residue by making wet mounts on microscope slides.
    b. Place screen in rift, then:
        (1) disturb bottom by moving stones,
        (2) remove organisms from screen and place in container,
        (3) sort out species.

c. Pick representative plants from various kinds present and place them in container.

d. Estimate the time it takes for the float to go a given estimated distance, estimate width and depth, and calculate flow in cubic units per time.

e. Get a bottom sample with a can, determine particle size with screen, and observe organic matter present.

2. Advanced Level

a. Run a known volume of water through the net or filter, then determine by microscope the number of kinds present per volume of water.

b. Collect bottom sample with Surber, Ekman, or improvised collector, then determine types present per unit area.

c. Collect representatives of all plant types using quadrat, if desired, then use keys to identify plants.

d. Calculate the flow using flow meter or watch, meter stick, and float.

e. Get a bottom sample using core sampler, Kemmerer Sampler, or Ekman Dredge.

f. Determine particle size by using differential settling or by using a series of different meshed screens.

g. Do a microscopic study of particle size.

h. Determine the percent of organic matter by massing, fire treating, and remassing.

V. Previous Studies

1. Some 6th graders delighted in drawing what they saw in their microscopes. They placed their drawings on the bulletin board.

2. A 3rd grade class was extremely interested in picking macroinvertebrates from a bottom sample.

3. Second-year biology students reacted strongly to the lack of diversity in a polluted bottom sample. They had thought that pollution just happened to the water.

4. A group of freshman students thought that their flow data were wrong because flow decreased as they went downstream. They

investigated further and found out that a water supply company was taking water from the stream.

5. A freshman class found that an undiluted water sample had a zero coliform bacteria count. However, the 1:10 and 1:100 dilutions had uncountable numbers. They were challenged to find a palatable solution.

VI. Limitations

Travel and clothing sometimes present problems. Keys are difficult to use. Teachers should emphasize general species characteristics and support the efforts of students to help them make particular identifications. Use pictorial keys if possible. Keying unknown organisms down to species often requires an expert. Don't require too much precision.

VII. Bibliography

American Public Health Association, Standard Methods for the Examination of Water and Wastewater, (12th ed.), American Public Health Association, Inc., 1965, pp. 634-690. These pages provide detailed descriptions of various collecting devices, counting cells, procedures, etc.

Edmonson, W. T. (ed.), Fresh Water Biology, (2nd ed.), John Wiley and Sons, Inc., New York City, 1959, pp. 1194-1197. These pages discuss the collection of plankton, vascular plants, and macroinvertebrates.

Mackenthum, K. M., The Practice of Water Pollution Biology, U. S. Department of the Interior, Washington, D. C., 1969, pp. 55-65. This is a very general text but covers simple techniques.

Morgan, A. H., Field Book of Ponds and Streams, G. P. Putnam's Sons, New York City, 1930. This book contains very good general information on collecting and preserving. It discusses growing organisms in the laboratory.

Pennak, R. W. C., Fresh Water Invertebrates of the United States, Ronald Press Co., New York City, 1953. Pages 727-735 give a brief description of equipment and methods and mentions the kinds of organisms which can or cannot be collected. Photographs are included.

Smith, Gilbert M., The Fresh Water Algae of the United States, McGraw-Hill Book Co., New York City, 1950. Pages 27-38 provide information on collection, preservation, and methods for studying fresh water algae.

B. Stream Deterioration Due to Effluents

I. Introduction

The purpose of this experiment is to show the student the effect of an effluent upon the fauna of a specific area within an aquatic system. Because of the nature of this experiment these activities would take place at a secondary level; however, with minor modifications it could be used at an elementary level.

II. Questions

1. To lead to the activity ask:

   What is an effluent?

2. Initiate the activity by posing:

   a. How could we determine the effect of an effluent?

   b. How could you collect the data?

   c. How could you compile the data?

   d. What do the data show?

   NOTE: After the students have discussed the ways in which the data can be compiled, introduce diversity index.

3. To continue the activity ask:

   Does the effluent affect the bottom dwelling organism in a stream?

4. To evaluate the activity ask:

   a. Did the population diversity change: How?

   b. Could you observe the changes that occur without a close examination?

III. Equipment

(Teachers should encourage their students to develop equipment whenever possible. Bacteriological equipment may be used if students are interested in further study.)

1. A plankton net

2. A Surber Sampler or an Ekman Dredge

3. Containers for collected plants and animals
4. Lab equipment - microscope, white enamel pans, hand magnifying glasses

IV. Procedure

1. Select a stream containing at least one effluent.
2. Pick sites 50 meters above and below the effluent which are suitable for your equipment. If the stream is wide, take three samples at each site, one close to each bank and one in the center.
3. Place samples in separate containers, identify by number, date, and temperature of water.
4. Make a map to show where the samples were collected.
5. If time permits, sample more than one effluent site.
6. During warm weather, refrigerate samples until for study in laboratory.
7. Pour contents of each bottle into separate white enamel observation pans.
8. Begin separating, counting, and tabulating.
9. Compile data.
10. Plan your time. Class discussions are very important.

V. Previous studies

1. Some 10th grade students were amazed at the number of species contained in one-square-foot samples.
2. One member of the team spent an afternoon in working a method for feeding information into the computer to develop our diversity index.
3. The team selected a stream named Needleshop Brook. Upon arrival at the stream, we searched for and found an effluent entering the stream. Samples were taken above and below the effluent entrance. Also, samples were taken 200 yards further downstream. Indexing indicated a sharp reduction of fauna directly below the effluent and a 70% restoration of the fauna further downstream.

4. The data collected at sites along a stream are shown in Figure B-1. As the stream had effluents added (increasing site numbers), the population diversity changed.

VI. Limitations

The appropriate stream may be difficult to find within a reasonable distance from the school and in an accessible area. Clothing and footwear sometimes became a problem.

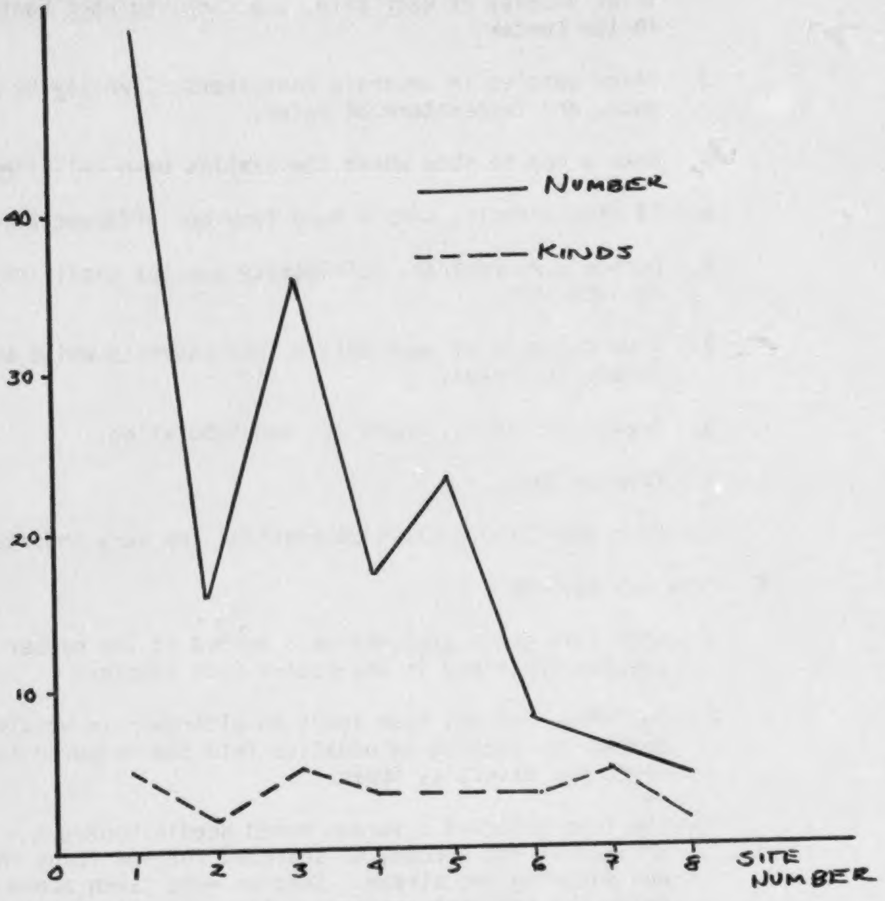


Figure B-1

VII. Bibliography

Coker, N. E., Streams, Lakes, & Ponds, Harper & Row, New York City, 1968.

Edmondson, W. T., (ed.), Fresh Water Biology, (2nd ed.), John Wiley & Sons, Inc., New York City, 1959.

Morgan, A. H., Field Book of Ponds & Streams, G. P. Putnam's Sons, New York City, 1930.

Pennak, R. W. C., Fresh Water Invertebrates of the United States, Ronald Press Co., New York City, 1953.

C. Stream Variation

I. Introduction

This is an introductory activity for 3rd through 12th graders. The students can easily become aware of how to sample bottom organisms and how population diversity varies with water quality. A short trip to two or more sites is required, but no specialized equipment is necessary.

II. Questions

1. Lead the activity by asking:

   Does the diversity index change as one goes downstream?

2. Initiate by asking:

   How could we test for this change?

3. Continue by asking:
   a. Why does the diversity change?
   b. Does it change drastically on the downstream side of an effluent?
   c. If so, what is the source of the effluent and can it be stopped?

4. Evaluate by:
   a. Listening to the ideas brought up in class discussions.
   b. Considering how well did the students work.
   c. Reviewing what seemed to interest them the most.
   d. Checking follow-up on the experiment (i.e., What is causing the change and how could the problem be best controlled?)

III. Equipment

1. Surber sampler
2. Three or more one-gallon or equivalent bottles for each sampling site

3. Preservative for keeping the organisms
4. Suitable clothing
    a. Boots, sneakers, etc.
    b. Shorts
    c. Rubber gloves (if working in contaminated water)

IV. Procedure

1. Collect bottom sample using the Surber sampler or another suitable collecting device.
2. Determine the number of species per unit area and the diversity index.
3. Compare and plot data of the stream.
4. Report and discuss findings.

V. Past Studies

A few students found that the stream steadily became worse as they proceeded downstream. They noted with interest the ability of the stream to cleanse itself from an effluent if given time.

Students in a freshman science course linked the population diversity with other factors - bacteria and chemical data - and found a relationship among the three. They felt a great sense of accomplishment in the study and thought that it was a worthwhile project.

VI. Limitations

Due to the nature of the experiment, the whole class might not easily do one stream. If there are too many people, it might be better to break up the class into small groups to survey other streams in order to arrive at a better picture of the aquatic ecosystem in that area. An alternative is to choose many sites along a stream.

Time is also a factor; field trips are generally very time-consuming, as is the counting of the organisms. It is neither advisable, nor necessary at this stage, to ask the students to identify down to the species level.

VII. Bibliography

Morgan, A. H., Field Book of Ponds and Streams, G. P. Putnam's Sons, New York City, 1930, pp. 26-45. This gives good general information on collecting and preserving and discusses bioassays.

Pennak, R. W. C., Fresh Water Invertebrate of the United States, Ronald Press Co., New York City, 1953, pp. 727-735. This gives a brief description of equipment and of methods and mentions the kinds of organisms which can or cannot be collected. It is illustrated.

D. Diurnal Study

I. Introduction

This diurnal activity deals with the study of the changes in carbon dioxide and dissolved oxygen in water over a 24-hour period by testing at regular intervals. Since the study takes place over a long (24 hours) period of time, students must arrange for rest between measurements or teams must be used. The investigation should convey both the biotic processes involved in the production of carbon dioxide and oxygen and provide a situation in which the student can independently perform a scientific experiment. To accomplish this, the following objectives should be kept in mind:

1. Promote creative thinking toward the solution of a proposed problem.
2. Motivate the student into collecting data to support his program for solving the problem.
3. Encourage the pursuit of the biotic processes involved in production of the dissolved gases and their interrelationship with each other and the abiotic factors affecting them.

II. Questions

1. Lead to the activity by asking:
    a. Is the concentration of dissolved gases in a body of water always the same?
    b. Are carbon dioxide and oxygen present in the same concentrations in a given body of water?
    c. Are the concentrations of oxygen and carbon dioxide constant in a 24-hour period or over a long period of time?
2. Initiate the activity by asking how you might determine whether the concentrations of these gases vary?
3. Continue the activity by asking:
    a. What factors may affect the concentrations of the gases?
    b. What effects on organisms are seen?
    c. How does the varying concentration of gases available to organisms affect the entire community?

4. Evaluate the performance of the students by considering questions such as:

    a. Did the students use more than one method for the determination of concentrations of gases?

    b. Could the student offer possible explanations, reasons for his results?

    c. Did students pursue a study of the physical factors affecting concentrations? How did they consider?

    d. Did the student consider the effects of gases on organisms?

    e. Did he make a study of these effects?

    f. Did he consider the effects on a community of organisms?

    g. Did he consider the effect of oxygen on food production or the reviërse?

    h. Did he pursue these possibilities?

    i. How well did the students work?

    j. Were they able to relate data and for an understanding of the whole system?

    k. Did they go on to consider the seasonal effects on gas concentration and what the results of such changes might be?

    l. Does the student consider the possibility of making a general statement about the possibility of oxygen and carbon dioxide being limiting factors in an aquatic environment?

III. Equipment

1. General Equipment

    a. Table for testing equipment

    b. Chairs

    c. Camping equipment, perhaps blankets, sleeping bags

d. Large flashlights

e. Alarm clock

f. Food and drink

g. Pencils and paper for recording data

h. Insect repellent

i. First aid kit

j. Sponge and paper towels

k. Masking tape for labelling

2. Equipment for dissolved oxygen determination

   a. Dissolved oxygen meter

   b. Winkler method equipment (have instructions available)

      (1) Manganous sulfate

      (2) Alkali-iodide-azide solution

      (3) Sulfuric acid

      (4) Sodium thiosulfate solution (.0375 N)

      (5) Starch solution

      (6) Distilled water

      (7) Collection bottles with ground glass stoppers

      (8) Graduated cylinder

      (9) Burettes and stands

      (10) Pipettes (2 ml. or 5 ml. calibrated in ml.)

      (11) Beakers: 125 ml., 250 ml.

      (12) Funnels for filling burettes

   c. Hach, Delta, or LaMotte kit

3. Equipment for carbon dioxide determination

    a. Collection bottles

    b. Hach, Delta, or LaMotte kits or alternative procedure

IV. Procedure

1. Oxygen Determination

    a. Dissolved oxygen meter

        (1) Place probe in water by casting without allowing probe to hit the bottom.

        (2) Check battery, calibrate instrument, and make temperature reading.

        (3) After setting temperature gauge, make oxygen reading and record data.

or,

    b. Follow procedures on dissolved oxygen procedure sheet (Appendix 1) for Winkler test, keeping the following precautions in mind:

        (1) Be careful to use the proper pipettes for different chemicals. Marking pipettes in order to distinguish them will help.

        (2) Use care in labelling so that chemicals are not confused.

        (3) Use extreme caution in handling sulfuric acid and alkali-iodide-azide solution. Pipette with CARE. If either is spilled, flush the area with water.

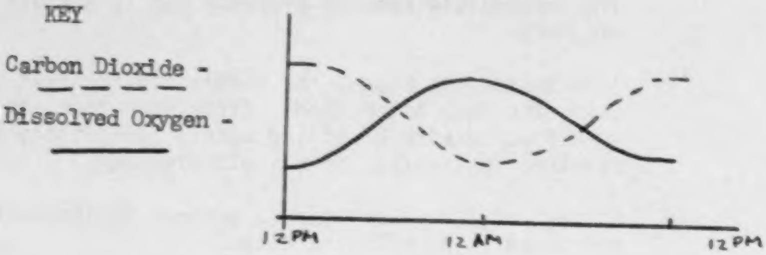
2. Carbon Dioxide

    a. A collection bottle should be placed upstream in the water, and it should be filled carefully with no splashing. As in Winkler, capping of the bottle should be done under water.

    b. Use kit procedure to determine concentration.

V. Past Studies

1. Participants in the Summer School Project at University School on a 9th and 8th grade level did a 24-hour study taking tests at 2-hour intervals and established an oxygen and carbon dioxide curve corresponding to the cycle.



2. Students on a junior high level participated in a 24-hour study taking the carbon dioxide and oxygen counts every 6 hours. When they found a sharp drop in the dissolved oxygen at 6 p.m., they explained it by noting the dense cloud cover that had formed since their last reading.

3. Juniors in high school conducted a 24-hour study during the fall and after noticing that the dissolved oxygen did not increase considerably from night to mid-day, they concluded it was due to the leaves which had fallen and blocked the sun's rays.

4. A group from a summer water pollution program did a 24-hour study of a local lake and noted that the carbon dioxide curve was highly irregular. They later realized that the lighting affected the test results by giving the samples a yellowish tint thus making the color readings in the test inaccurate.

5. In 1961 at Webster Lake near Tilton, N. H., a group of summer trainees recorded the following study:

   a. Selection of a site was made after consideration of factors including accessibility of the site and problems concerned with setting up and use of the equipment.

   b. The equipment was set up inside the Webster Lodge. At 24-hour intervals the tests for carbon dioxide and dissolved oxygen were conducted. Two water samples were obtained by filling ground glass collection bottles with water from the site, taking care to fill the dissolved oxygen bottle completely, thus preventing aeration from within the bottle. At this time, the dissolved oxygen reading and temperature of the water were taken with the Dissolved Oxygen Meter. The purpose of taking two dissolved oxygen tests was to make a comparison between methods. However, the Winkler-Azide Method failed to give reasonable results probably due to a fault in the reagents.

c. Once inside the Lodge, the carbon dioxide test was run using the Hach Kit Method. After each test, the bottles were flushed with distilled water. (Sterility is not required in testing for dissolved gasses.)

d. As part of the observations, general weather conditions are noted along with the data.

Time	Temp °C	O_2 (ppm)	CO_2 (ppm)	Remarks: (light, air temp., wind level)
10:15 pm	19	3	8	Dark, warm, and still
12:15 am	19	4	6	Water disturbed due to human activity Dark, cold, and still
2:15 am	18	3	8	Same as 12:15 am
4:15 am	17	5.2	8	Cold, still, lighter
6:45 am	17	7.5	6	Same as 4:15 am
9:15 am	19	8	4	Water disturbed due to human activity
11:00 am	20	7.5	4	Water disturbed due to human activity Light, warm, still
1:00 pm	21	6.5	4	Same as 11 am
3:00 pm	21.5	7.5	4	Water disturbed due to human activity Light, hot, windy
5:00 pm	23	6.5	4	Same as 3 pm
7:00 pm	22	8	6	Water disturbed due to human activity Dark, still, warm

e. Dissolved oxygen and carbon dioxide concentration change as a result of animal and plant respiration and photosynthesis. It may be that the dissolved oxygen was low during the first testing time because the day had been an overcast one and, perhaps, less dissolved oxygen had been formed by the photosynthesizing plants.

Dissolved oxygen concentrations are inversely proportional to temperature change. For example, between 5 p.m. and 7 p.m. there was a decrease in temperature accompanied by an increase in dissolved oxygen.

f. Dissolved carbon dioxide and oxygen vary in concentration within a 24-hour period due to a variety of physical characteristics which change as the day progresses. It would be interesting to determine whether this fluctuation in gas concentrations might produce noticeable effects in the biotic community of the lake.

VI. Limitations

1. Make sure the equipment is complete to prevent the necessity of returning to the lab.

2. Plan your equipment with the physical characteristics of your site in mind (i.e., mosquitoes).

3. Obtain some method of lighting other than lights that must be held (i.e., a lantern).

4. Location:

    a. Have easy access to your site. Problem locations would be:

        (1) forest with dense undergrowth

        (2) steep banks

        (3) water which drops off quickly at the banks

    b. Locate your site and set up equipment before dark.

5. Surviving the night:

    a. Proper clothing, a change of clothes and a sleeping bag are needed to insure the semicomfort of the participants.

b. Quick energy food is needed.

c. In most cases, insect repellent is a must.

VII. Bibliography

Benton, A. H., Field Biology and Ecology, (2nd ed.), McGraw-Hill Book Co., New York City, 1965.

Billings, W. D., Plant, Man and the Ecosystem, (2nd ed.) Wadsworth Publishing Co., Belmont, Calif., 1970.

Buchsbaum, Ralph, Basic Ecology, Boxwood Press, Pittsburgh, Pa., 1957.

Kormondy, Edward J., Concepts of Ecology, Prentice Hall Biological Series, T. H. Inc., Englewood Cliffs, N. J., 1969.

Life Science Series, Ecology, Time, Inc., New York City, 1969.

Odum, Eugene P., Fundamentals of Ecology, (2nd ed.), W. B. Saunders Co., Philadelphia, Pa., 1971.

E. Population Diversity Index

I. Introduction

This activity enables the student to determine the species population of macroinvertebrates in a stream. The student may also determine by investigation if the diversity index changes as one samples at random sites downstream. The activity will acquaint students with macroscopic sampling techniques and will, hopefully, provide them with results that will initiate other kinds of water quality tests and activities. Seventh graders and above may do this activity.

II. Questions

1. To lead to the activity:
    a. How many kinds and numbers of macroinvertebrates are in the stream?
    b. Do you think this diversity index should change as you go downstream?
2. Initiate the activity with: Where are they found and how can they be collected?
3. Continue with: If there is a change in the diversity index, how can you account for it?
4. Evaluate the students by asking:
    a. How many species were present in the students'samples?
    b. Were the samples representative?
    c. Given the change in the diversity index, did the students account for this change?
    d. Were the students interested in the activity?
    e. Did any of the students want to pursue the activity to a greater depth?

III. Equipment

1. Basic Introductory Level
    a. Hip boots, screen, (for bottom dwelling organisms - close mesh), or cloth (i.e., nylon)

b. Collecting jars with preservative, if it is being used; shallow pan; and forceps

c. Pan with white background

2. More Advanced Level

a. Surber sampler (for other samplers see Standard Methods pp. 673-83)

b. Can to rinse attached invertebrates to bottom of net; collecting jars; shallow pan; forceps

c. Pan with white background; key to identify invertebrates

d. Dissecting scope to facilitate identification

IV. Procedure

Choose several sites randomly spaced along the stream. At each site take three samples such that the area is well covered. Water should not be too deep or too shallow and fast running. Avoid large rocks; find gravelly bottom with hand-size stones or little larger. Try to make each sample site the same type of bottom and same area.

1. For Basic Level

a. Place screen, so that it will trap macroinvertebrates that have been loosened from upstream, at the chosen sites. Disturb bottom by moving stones above screen.
Note: Area should be constant for all sampling done. It may be desirable for students to wear boots.

b. Remove organisms from screen and place in a suitable container.

c. In the lab, place the specimens in pan with white background; separate them as to kinds and number. (This will determine species population.)

d. Assign letters to the specimens, each specimen having a letter, with specimens in each group having consecutive numbers. For example, if there are 37 worm-like specimens with black heads, these might be in Group A and have numbers 1 through 37; 14 snails of one type might be Group B and have numbers 38 through 51, and so on.

e. Randomly select (by putting numbers in a hat and pulling them out, for example) numbers 1 to 200 and list them.

f. Determine the number of "runs" (the numbers of continuous series of similar organisms). If the numbered specimen is in the same group as the one immediately preceding, it is part of the same run; if not, a new run is started (it does not matter that the specimen is part of a run three or four runs back; we are concerned only with the specimens immediately following one another). For example, take the following list, with groups assigned. Suppose, that the first number chosen is number 10. Number 10 organism is from Group A. This will begin run number 1. Organism number 3, chosen next is of the same Group A and is therefore also included in run number 1. However, the next organism, number 6, is of Group D. Hence, a new run, number 2, has begun. The remainder of the runs are formed in a similar way.

Organism number	Group	Run
10	A	1
3	A	
6	D	2
7	B	3
2	A	4
5	C	5
4	C	
9	B	6
8	B	
1	A	7

These are a total of 7 runs in the 10 spcimens listed.

g. The total number runs reported both as total no./200 specimens and as a Diversity Index.

$$\text{D.I.} = \frac{\text{number of runs}}{\text{number of specimens}}$$

2. For Advanced Level

a. Place Surber sampler in water at chosen sampling site. Pick up stones and remove organisms so that they will flow into the collecting net. Note: Be sure to collect all possible organisms in the square foot area.

b. Remove sampler from water and transfer organisms to collecting bottles. Note: It may facilitate transferring organisms if the organisms are first placed in a shallow pan and then in the collecting jars.

c. In the lab, place the specimens in pan with white background; differentiate them as to kind and total numbers of each kind.

d. If the students are interested, they should identify the organisms they have collected with the aid of a dissection scope and a key. (This would be for advanced students and would be useful to relate organisms being found at different sites on the stream.)

e. To determine the diversity, one divides the number of types by the square root of the total numbers of individuals for all samples taken at each site.

$$D = \frac{S \quad (\text{\# of Species})}{\sqrt{N} \quad (\text{total \# of individuals})}$$

For further interpretation of data consult The American Biology Teacher, "Patterns of Numerical Abundance of Animal Population," by Jerry Wilhm, Vol. 31, No. 3, pp. 147-150, March 1969.

V. Previous Studies

1. A freshman class sampled 22 different locations on a watershed, collected and massed the macroinvertebrates.
2. A 2nd-year biology class used this method to determine species diversity.
3. A field study of this type was used by sophomores, to illustrate the numerical abundance of a population of grasses on a lawn.

VI. Limitations

Ample time should be provided for collecting samples. Sites should be well planned before class activity. Since this activity will probably take longer than one setting, specimens may be kept in preservatives until time allowed; however, it is best to work with live samples (they can be kept up to 4 days by refrigeration).

Time is required in transferring the specimens from net to jar (they tend to cling to the net). Often there is a feeling of inadequacy and a consequential fear to try this activity. If many samples are obtained, they should be clearly labeled to avoid mixing; keys are often difficult to apply.

VII. Bibliography

American Public Health Association, Standard Methods For the Examination of Water and Wastewater, (12th ed.), New York City, 1965. This gives a complete listing of all bottom fauna sampling methods and how to use them, pp. 673-682.

Mackenthum, K. M., The Practice of Water Pollution Biology, Department of the Interior, Washington, D. C., 1969. It gives a semi-complete listing, but for more information on sampling methods see Standard Methods.

Morgan, A. H., Field Book of Ponds and Streams, G. P. Putnam's Sons, New York City, 1930. Both of these books are good if you are looking up the genus species of your specimens.

Pennak, R. W. C., Fresh Water Invertebrates of the United States, Ronald Press Co., New York City, 1953.

The American Biology Teacher, Vol. 31, No. 3, March 1969.

F. Bioassay

I. Introduction

In order to determine the effect of harmful dissolved solids on a microcosm, the minimum lethal dosage must be determined. This can be done by experimenting with different concentrations of dissolved solids and noticing the effect over determined periods of time. Seventh graders and up may complete this activity.

II. Questions

1. Lead into the activity by asking:
    a. How could we test the stream's fauna in relationship to abiotic factors?
    b. Are certain combinations of chemicals synergistic? If so, how could we test for this?
2. Initiate the activity with:
    a. Where could the experiment be best controlled?
    b. What type of test organisms would be best suited for our study?
3. Continue with:
    a. What do the varying "kill" times indicate?
    b. How could this (kill time) be minimized?
4. Evaluate the students by considering:
    a. Do the students "stick with it" when the control dies off first for some strange reason, yet still continue anew?
    b. Was time used wisely (as opposed to hacking)?
    c. Did the students try to do as quantitative a study as possible?

III. Equipment

Like many other experiments in the ecological perspectives group, the following materials are fairly standard. The following pieces are for a quantitative rather than a qualitative study.

1. Battery jars
2. Graduated cylinders
3. Aerators and plastic tubing
4. Test chemical
5. Test animals (fish, macroinvertebrates, plankton)
6. Nets
7. Labels and markers
8. Sample jars
9. Water from which samples are taken

IV. Procedure

1. In the lab, mark all battery jars used.
2. Prepare each jar with the liquid required. REMEMBER the control!
3. Begin to aerate the jars 30 minutes before you put in any of the test animals.
4. Collect test animals. (Be sure they are acclimatized to the lab.)

   For further precautions see the limitations section.
5. After the test animals are accustomed to the lab, transfer them to the test jars.
6. Note the time. Depending upon time limitations, you may want to check the jars every half hour or daily (obviously the half hour is more quantitative than the daily check).
7. Remove all dead fish from the jars.
8. For each jar, graph fish kill vs. time of individual deaths.
9. After 96 hours or 100% fish kill, which ever comes first, end the test.

V. Past Studies

Using the procedure above, studies have been done as to the effects of an endotoxin produced by the dying of certain blue-green algae. The algae were killed by copper sulfate at 4 ppm. The test animals were minnows. The first study did not succeed due to the use of distilled water instead of stream water. A second study was immediately undertaken using the above procedure.

Another group of students ran a toxicity test on $CuSO_4$ and found that after 3 hours a 100% fish kill occurred.

VI. Limitations

1. In doing bioassays, keep in mind some of the following factors:
    a. Temperature
    b. Oxygen
    c. Nutrients
2. As a safeguard against possible killing of the fish in the lab, try to make the water in the battery jars the same temperature as was found in the stream. Even more important is the oxygen. Remember that the fish need O_2; try to get them as quickly as possible back to the lab to the aerators. Stream water is chosen in lieu of distilled for it was discovered that the fish would die fairly quickly without the necessary nutrients, even though the O_2 and temperature were satisfactory.
3. As mentioned before, time is a very important factor in that there is a considerable amount of time taken up in catching the test organisms.

VII. Bibliography

American Public Health Association, Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Inc., New York City, 1950. This gives the standard tests for CO as well as giving identification plates for some fresh water algae.

Smith, Gilbert M., The Fresh Water Algae of the United States, McGraw-Hill Book Co., New York City, 1950. This is a general text on the identification and classification of fresh water algae.

G. Plankton Growth in Relation to Light

I. Introduction

The purpose of this activity is to discover what relationship, if any, exists between the presence of light and algae growth. Students make a photometer, then use it to measure the extinction of light in a still body of water. Data from the light measurements are then compared to data on the plankton population of the water. This activity is most successfully performed by students in grades 7 to 12, and requires that the students have a basic understanding of the process of photosynthesis.

II. Questions

1. Questions leading into the activity:
    a. What do green plants need to grow?
    b. If they don't get what they need what happens to the plants?
    c. What happens if a plant can get all the water and light it can use?
    d. What happens if a plant can get all the light it needs but can't get enough water?
    e. What happens if a plant can get all the water it needs but can't get enough light?
    f. Where is a place where plants can get all the light they need, but not enough water?
    g. Where is a place where plants can get all the water they need, but no light?
2. Questions initiating the activity:
    a. In a nearby still body of water, as you go towards the bottom, do you reach a point at which there is no light or less light than at the surface?
    b. How many plants would you expect to find there (at the bottom) as compared to the number you would find at the top?
    c. How are we going to prove that there is a place in the water where there is less light?
    d. How are we going to prove that in this place where there is less light, that there is also less plant life?

3. Questions which continue the activity:

    a. Does anybody know how to snag up a lot of plants from the water at a particular depth?

    b. Does anybody know any ways to measure how much light there is in a given place?

    c. If you had a camera light meter, how could you use it under water?

    d. If you did not have a camera light meter, could you make a simple instrument to measure light under water?

    e. What else can you think of other than a light meter that would be sensitive to light?

    f. How could you arrange to have a known amount of light at a known depth so that you could measure the light the plant took in?

4. Evaluating the student's efforts:

    a. Does the student have a reasonable understanding of the way in which plant growth is dependent on light?

III. Equipment

1. Pond or other suitable body of water

2. A boat, pier, bridge, or bank which will allow students to lower samples to a depth which will demonstrate a measurable attenuation of light

3. A light sensitive device such as:

    a. Camera light meter in plastic bag or similar waterproof container and device (such as diving mask) for reading light meter under water

    b. Homemade photometer: an instrument of this sort can readily be assembled with a variable-register photocell and an ohmmeter from the school physics lab.(The photocell can be purchased for a dollar or less from a local electric supply house. It usually comes with two wires attached. If the wires are clipped to the leads of the ohmmeter, light registers directly as (milli) ohms of resistance. Plastic bags or other waterproofing can be applied as necessary, a project which can be readily completed with the assistance of a senior physics student or a general science instructor.)

4. Equipment for collecting plankton:
    a. Plankton net
    b. Homemade device such as cloth bag or pillowcase on coat hanger frame dragged through water on a string
5. Microscope for observing plankton
6. Measuring instrument for determining depth
    a. Meter stick
    b. Knotted or marked cord
7. Containers for samples

IV. Procedure

1. Select a site.
2. Measure light at depth. Readings can be taken continuously or at intervals which are convenient from the surface to the bottom or point of light extinction.
3. Collect plankton at depths corresponding to depths measured for light intensity.
4. Evaluate plankton population at each level.
5. Graph and correlate data to demonstrate relationship between ligh and plankton growth.

V. Previous Studies

In a study done by students at Peasoup Pond in Franklin, N.H., it was found that only 5% of the light striking the surface of the pond penetrated to a depth of 4 feet. Near the surface of the pond several types of green algae were present in moderate concentration; no algae was found in samples at a depth of 4 feet

VI. Limitations

The pond used for the study has to demonstrate enough attenuation of light so that there will be a measurable difference in plankton concentration from the surface to the bottom. If the water is too clear, plankton will avoid the very bright sunlight in the 1 to 2 feet of the pond, and figures could be produced that would show increasing plant growth with decrease of light. A very deep pond or lake which was stratified for temperature could show a difference in photosynthesis on opposite sides of a thermocline.

VII. Bibliography

Benton, A. H., and W. E. Werner, Field Biology and Ecology, McGraw-Hill Book Co., New York City, 1966.

Ruttner, Franz, Fundamentals of Limnology, University of Toronto Press, Toronto, Canada, 1953.

Smith, Gilbert M., Fresh Water Algae of the United States, (2nd ed.), McGraw-Hill Book Co., New York City, 1950, pp. 14-15.

H. Water Quality Comparisons by Diversity Index

I. Introduction

The purpose of this investigation is to compare the diversity index of two separate waterways; one with obvious pollution, the other apparently clear. Suitable locations may be found through observation of the site, comparing basic properties noticeable fish kills, sewer or pipe drainage entering lake, noticeable algae blooms, and odor of water and lake shore. Young students could do a fair job with sample collecting, but perhaps only high school students should attempt complicated type classification.

II. Questions

1. To lead to the activity, ask how many kinds of plants and animals are present at this location.

2. Initiate the activity by posing, how are you going to collect these specimens?

3. Continue the activity with:

    a. Does the water depth have any effect on the numbers and kinds of organisms present?

    b. Does pollution affect the total number of animal and plant samples collected?

    c. Are there any specific plant or animal groups that are affected more than the others by pollution? (This may be a benefit as well as a detriment.)

4. Evaluate the performance of the student by considering questions such as:

    a. Did the group collect a representative sample of the area?

    b. Did all students appear to be working willingly and to their capacity?

    c. What part of the investigation seemed to interest them most?

    d. Were the students able to draw adequate conclusions to satisfy the problem?

III. Equipment

(Equipment can easily be adapted to availability. Even for advanced groups sophisticated equipment is not needed.)

1. Fine mesh cloth to filter bottom samples for microbes
2. Screening to screen out larger invertebrates
3. Seines or fish nets to collect small fish or aquatic insects
4. Containers for holding plant and animal specimens
5. A small rubber boat or raft (any floating craft that will hold one person)
6. Meter stick for measuring depth of water
7. Sounding line
8. Microscope

IV. Procedure

1. Collect all varieties of plants present at a shallow depth.
2. Seine or net samples of small fish, amphibians, water insects, or other forms of animal life at shallow depths (up to one meter).
3. Screen out large invertebrates from soil samples at shallow depths with coarse screening.
4. Examine the lake bottom at shallow depths for bottom dwellers (snails, clams, mussels, etc.).
5. If the group is mature enough, repeat procedures (3 & 4) listed above, at water depths of 2 and 3 meters.
6. Bring material back to laboratory, sort as to like kinds, and classify all specimens where possible.
7. Compare collections from each site and determine the effect pollution has on organism diversity.
8. Within each waterway, determine what effect water depth has on numbers of individual specimens.

V. Previous Studies

1. A group of high school students was surprised to find that the number of mussels per square meter was greater in a polluted lake than in a nonpolluted one. This led to speculation as to how far this pollution could go before the trend was reversed.

2. In comparing lake bottoms from polluted and nonpolluted water systems, the students noted that polluted sand bottoms were covered with a layer of silt or mud; the clear lakes had much less sediment. They wondered whether the increased vegetation could have anything to do with this situation.

3. The presence of large masses of spirogyra in the shallows of a still lake became a signal to a 6th grade class that the water was polluted.

VI. Limitations

Class size may hinder effective control and accomplishment of this investigation. Transportation is always a problem. In studying water that shows pollution signs, care must be taken to protect the student from contamination. If adequate protection is not available, then the site should be ignored. Classification should be attempted according to the ability and maturity level of the class. Keying to class or order is adequate for younger groups.

VII. Bibliography

Jacques, H. E., Plant Families--How to Know Them, Wm. C. Brown Co., Dubuque, Ia., 1941. A general key is given for all plant families.

Morgan, K. M., Field Book of Ponds and Streams, G. P. Putnam's Sons, New York City, 1930. It gives helpful information on collecting and classification, and it has some helpful photographs.

Needham, J. G., and P. R. Needham, A Guide to the Study of Fresh Water Biology, Holden-Day, Inc., San Francisco, Calif., 1969.

Pennak, R. W., Fresh Water Invertebrates in the United States. The Ronalds Press Co., New York City, 1955. This is a good guide to fresh water forms most often found in common waterways of New England. Keys are quite easily followed by younger students.

Prescott, C. W., How to Know the Fresh Water Algae, Wm. C. Brown Co., Dubuque, Ia., 1964. This contains a rather comprehensive and difficult key to the algae of fresh water. The practiced student has little or no trouble finding most species.

Smith, Gilbert M., Fresh Water Algae of the United States, McGraw-Hill Book Co., New York City, 1950. It contains a complicated key to the algae which should not be used by the inexperienced student.

U. S. Department of the Interior, Biological Field Data for Water Pollution Surveys, U. S. Government Printing Office, Washington, D. C., 1966. This is a good book for terminology and equipment description for water sampling and could be helpful for even the very young student.

Ecological Perspectives

I. Algal Blooms and CO_2

I. Introduction

The purpose of this investigation was to determine the regularity properties of CO_2 in relationship with algal blooms. It might be best handled by students that have taken either biology or chemistry. This could also be handled, although maybe at a less quantitative level, by those who have not yet had such courses. The test is conducted by running CO_2 and algae counts and plotting the resulting graph between the two.

II. Questions

1. Lead the activity by asking:
   a. How do plants affect the life in a given body of water?
   b. What do the plants need for growth?
   c. What gases do plants give off?
   d. What gases are utilized by the plant in the photosynthesis process?
2. Initiate the activity with:
   a. How could we test for these gases (i.e., why test for them)?
   b. Would there be a relationship between the amounts of certain gases and the amount of algae?
3. Continue the activity with:
   a. Could these gases be controlled?
   b. Does an algal bloom control the CO_2 or the CO_2 control the bloom?
4. Evaluate the students by considering:
   a. Do we have enough data to reach a valid conclusion?
   b. Did the students understand the procedure?
   c. Did they try to refine the procedure in its rough spots?
   d. Were they inspired to take on new outgrowths?

III. Equipment

1. Basic level

   a. Method for testing CO_2 (Hach, Delta, LaMotte, etc.)

   b. Sample bottles

2. More advanced level

   a. Same as above

   b. Bioassay equipment using plankton as organisms

IV. Procedure

1. Basic Level

   a. Take CO_2 test.

   b. Take water samples for plankton analysis.

   c. Count the plankton.

   d. Graph the results: number of plankton vs. corresponding CO_2 levels.

2. More advanced level

   a. Follow the preceding procedure.

   b. Run a bioassay using plankton as test organisms.

   c. Purpose: to create an algal bloom.

   d. Introduce CO_2 into the system at different levels.

   e. Keep close tabs on the pH.

   f. Test for CO_2 changes.

   g. Discuss the importance of a rise or fall of CO_2 in the system.

   h. Graph the resulting data.

V. Past Studies

Some students while investigating the first question noticed in their study that certain data when plotted showed an interesting bell-like curve. This curve indicated a high and/or low range at which algae might exist in bloom conditions. Time ran out before sufficient data had been collected in order to answer the last question.

Other students, for a recent lab report undertaken in a 10th grade chemistry class, studied this area. They found that there were certain limitations in running a bioassay in the lab using CO_2 as a nutrient. The lab was not a true success in that the test organisms died because of the increase of pH caused by the added CO_2. This did, however, force them into the field where they found varying concentration of CO_2 occurring, naturally. This made them ask themselves why the pH was higher in the ponds and lakes than in their bioassays. Thus, they were hot on the trail of a possible natural-existing buffer in the water.

VI. Limitations

The main limitation in the exercise lies in the advanced level of the experiment. That is, the CO_2 levels in the different jars were of such concentrations that the CO_2 in the water caused a significant drop in the pH. This is because carbonic acid is formed (when CO_2 changes to carbonic acid.) This is why it is felt that a suitable buffer was needed.

Another important limitation is that most CO_2 tests are no more than a free acidity test in that phenolphthaleine is the indicator. Therefore, if the sample that you are working a test for has a higher pH than 9, any CO_2 that is present will be masked by this alkalinity. Perhaps a possible outgrowth of this could be a chemical that would neutralize the carbonic acid in the water which then could be measured.

VII. Bibliography

American Public Health Association, Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Inc., New York City, 1965. Pages 78-85 and pages 739-744 give the standard tests for CO_2 as well as giving identification plates of some fresh-water algae.

Smith, Gilbert M., The Fresh Water Algae of the United States, McGraw-Hill Book Co., New York City, 1950. This is a general text on the identification and classification of fresh water algae.

J. Bottom Core Sampling

I. Introduction

This activity is designed to acquaint high school students with bottom sampling in general and organic analysis of bottom samples in particular. Approximately three 1-hour periods will be required. The setting for the investigation should be one which will enable the student to obtain a core with relative ease as well as a core which will evidence clear layering from season to season. Generally the best locations are around bodies of water which undergo regular flooding every spring and gradual emergence during the summer months. The dark layer which will be noted usually represents the rather fine organic material that is deposited in the shallow and calm waters of the summer season while the alternating band of coarser and lighter colored gravelly material is representative of sediment which is laid down in the more turbulent waters of the springtime. It is important that students practice taking cores beforehand and develop skill in driving the core sampler and retrieving the samples. See Figure 3J-1.

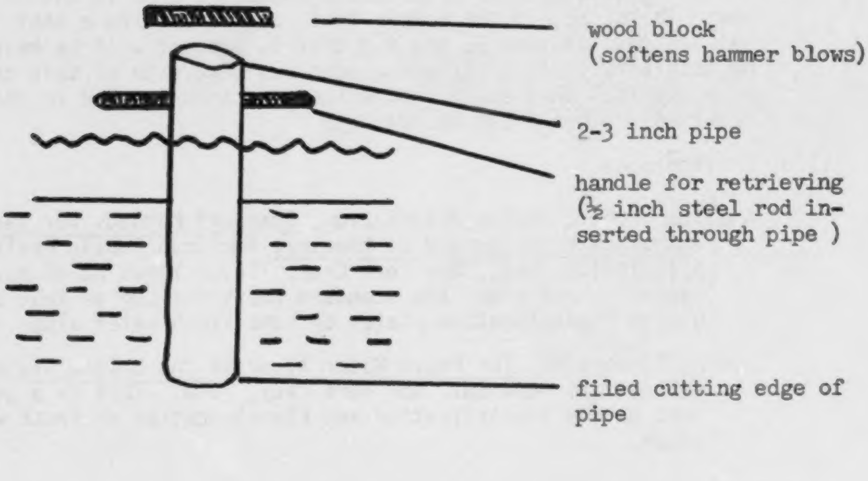

wood block
(softens hammer blows)
2-3 inch pipe
handle for retrieving
(½ inch steel rod inserted through pipe)
filed cutting edge of pipe

Figure 3J-1

II. Questions

1. Lead to the activity by asking:

   a. Can you think of any way to obtain a record of some of the materials which have been suspended in our streams and lakes and deposited on the bottom over the past several years?

   b. Explain.

2. Initiate the activity with:

   a. Do you feel that the amount of organic material being laid down each year in a specific body of water is related, in some way, to the amount of pollution that this area has experienced?

   b. Explain.

3. Continue the activity with:

   a. Can you think of several different ways to analyze chemical variations and interpret the ecological history which is indicated in core samples?

   b. Explain.

4. Evaluate the students' work by noting what significant differences they discovered in the different layers and by evaluating how they reconstructed the ecological history.

III. Equipment

1. Core sampler
2. Large flat cake pan or other suitable pan for placing the core to be analyzed
3. Drying oven
4. Spatula
5. Cm. scale
6. Merck burner (Bunsen burner may be used if a Merck is not available)
7. Ring stand

8. Triangle

9. Extra large crucible, size 3, (an evaporating dish may be used if a crucible is not available)

10. Cent-O-Gram balance

IV. Procedure

1. The core may be obtained and removed immediately by gently sliding it out onto a cake pan.

2. After bringing the sample to the lab select the areas for analysis. Cut sample bands of desired width (approx. 1 cm.) and place each band to be analyzed in a previously weighed crucible.

3. Dry sample at 70-80°C in an oven overnight to remove moisture. (An alternate method of drying is to line the core tube with vaseline before the sample is taken and allow the sample to dry in the tube over the weekend or for 2-3 days and then remove. The core then has less tendency to fall apart in the removal process. The outer edge in contact with the vaseline must be shaved off before analysis.)

4. Weigh each crucible and dried sample.

5. Heat sample for 45 minutes to burn off all organic material. (If the art department has a firing oven, the sample may be fired until it comes to constant weight.)

6. Cool and weigh.

7. Heat again for 15 minutes, cool, and weigh. If weights agree within ±0.03 grams, the sample can be considered to be at constant weight. If sample is not at constant weight heat, cool, and weigh until it is.

8. Determine the weight of sample.

9. Determine percentage of organic material.

V. Past Studies

A core sample was obtained for the first site of the Winnipesaukee River. Although several cores were obtained, only one was used for analysis due to limited time. Choices of where to take samples from the core will vary from sample to sample according to mud stratification. In our sample, layers of similar given grain size (fineness) were chosen. We used Bunsen burners for heating and glowing embers were noted in the samples up to 30 minutes after heating began. Our samples were left for 2 hours and the second heating gave constant weights. No effort was made to determine minimum heating time with Bunsen burners. Heating time would vary according to the percentage of organic material present. The following results were obtained:

Sample	Location on Core	% Organic Material
A	1st cm. from top	4.9%
B	2nd cm. from top	2.2%
C	11th cm. from top	1.5%
D	12th cm. from top	3.1%

From this one test no definite interpretations can be made. Since class investigations would be expected to produce more analyses, the significance of any patterns which might develop should be interpreted with respect to the ecological history of the area.

VI. Limitations

1. Heating to burn organic materials may require much extra time depending on percentage of organic material present and how hot a flame is available.
2. If cores are obtained with no stratification it is difficult to determine where to take samples.

Chapter 4 Social and Political Factors

A constructive approach to pollution problems requires more than a knowledge of pollution results; we also need to understand the human motives and actions that produce them, as well as comprehend the political process that we must initiate to change those results. It is difficult to define or limit the scope of the activities which appear in this section, for in a general way, virtually all human activity is either social or political.

There are several general approaches that may be taken on this subject. One of the most direct approaches to social and political factors, however, is to begin with the present, find out how we got here and where we should go from here. To find out where man is, the student must begin to relate the scientific aspects of pollution to the social and political factors. The question, "Where are we now?", must be answered as completely as possible. Our political institutions must be defined and evaluated to see what hope for solutions lies in them. Existing laws must be examined as well as procedures for enforcement. In other words, the political structure at all levels must be examined to determine what type of vehicles exist and what, in fact, is going on. This in itself is not an easy task; some of the activities which follow, such as the construction of government models, clearly demonstrate the overlaps in authority, and the ambiguous seats of responsibility which now exist among government agencies.

Next, to determine what factors allowed this situation to develop, it is beneficial to study the history of our laws and those political institutions relevant to water pollution, as well as the feelings and sense of responsibility of various individuals and companies. The history of the relevant laws can be determined through research. Most states have law libraries available to the public. Others may be found in a local courthouse, university,or even a local attorney's office. Any of these is a good place to begin.

Of particular value is the development of industrial polluters. Each business can be analyzed from many points of view. Its record of water pollution violations, obtainable from the state pollution commission or whatever body is charged with the regulation of water quality in your state, is of particular interest. A company's economic history can be determined from past annual reports and corporate histories available either from the company itself or through a local brokerage house.

The state engineers associated with water quality can be queried, and corporate executives should be questioned. They are able to relate past, present, and future policies of the corporation in terms of their responsibility to stockholders, the community in which they operate, and the natural resources they consume or destroy. Very often decisions made by management concerning natural resources are made according to narrow, inadequate economic criteria. They are often not conscious that decisions concerning the management of natural resources involves the allocation of an essentially fixed resource.

Social and Political Factors

Personal interviews are very valuable in recognizing the difficulty in reaching solutions when the problem involves particular people whose rights, prejudices, and very often, simple lack of interest, must be considered. Often games, particularly those which utilize role playing, are also helpful in further illuminating these conflicts.

In conducting these interviews, students may probe into other competing considerations for the use of our resources.

This brings the students to the last phase of investigation: "Where do we go from here?" Do we have an obligation to future generations to maintain the quality of our natural environment, and, if so, how do we go about preserving it? Model legislation activities, as well as the formation of clubs and lobbies, are helpful in focusing attention on specific problems.

This section also involves communication. Environmental problems which already exist as well as those pending must be recognized and widely discussed.

Possible alternatives must be made known before any final decisions concerning our natural resources are made. If a lobby is to be successful, it must have wide support; if model legislation is to be enacted, it, too, must have the support of citizens and legislators alike. All of this involves communication of one kind or another. Students are more than willing to undertake activities in this area and may utilize any media from video tape to statistics.

Social and Political Factors

A. How to Talk Back to Statistics

I. Introduction

This activity is designed to help students read articles on water pollution critically; it should also help them increase their general awareness. Select the articles according to the groups' reading ability and their scientific background. Do not underestimate the students' ability to follow news articles; they are very curious about news.

II. Questions

1. To lead to the activity, ask:

   Is the information you read in your article reliable?

2. To initiate the consideration of the statistics' reliability, ask:
   - a. Who says so (where did the data come from)?
   - b. How does he know (qualify the source)?
3. To continue refining the evaluation of the article, ask:
   - a. What is missing?
   - b. Did somebody change the subject?
   - c. Does it make sense?
4. To evaluate the students' success, check the following:
   - a. The student should formulate an opinion on the article and back up his views with several important factors.
   - b. The student should be able to present the complete subject in an acceptable manner.
   - c. The student should be able to demonstrate particular types of distortions or misusage of data by converting the data to a low quality advertisement or poster.

III. Equipment

Materials for writing and illustrating should be available. Copies of the article must be made or bought. If the students rework the data, serious consideration should be given to publishing their work.

IV. Procedure

1. Get an article, make copies, and assign the reading.
2. Have a class discussion where you introduce the questions.
3. Let the students do another version or let the students seek out several views on the same subject and then reapply the questions to be able to compare the articles.

V. Previous Studies

Seniors were required to subscribe to the New York Times and to read front-page articles which dealt with statistics or data. They could be counted upon to read about drugs, economics, and, in particular, water and air pollution. After reading 3-5 articles and evaluating them, the critical evaluation based on the five questions became automatic. A carryover into the evaluation of advertisements was notable. When students presented data as a result of polls they had taken, usually they did not do a superficial job. This could carry over into lab conclusions and evaluations.

VI. Limitations

Reproduction of articles for educational purposes is usually permissible. Make it a policy to acknowledge sources and, when possible, tell the author you used the material for educational purposes.

VII. Bibliography

1. Freund, John E., Modern Elementary Statistics, Prentice Hall, Inc., Englewood, N. J., 1960. This text acquaints students with the theoretical aspects of statistics. This is recommended for high school students.
2. Huff, Darrell, How to Lie With Statistics, W. W. Norton and Co., New York City, 1954. This book is a study of the use and misuse of statistics. It is written humorously and can be understood by junior high students. It is recommended for all who undertake this activity. This is available in paperback.
3. Johnson, D. A., and W. H. Glenn, The World of Statistics, Webster Publishing Co., Manchester, Mo., 1961. This is a book on the basics of statistics for junior high on up.

4. Reichman, W. J., Use and Abuse of Statistics, Oxford University Press, New York City, 1962. This is a general work on statistics designed for the high school student which covers the calculation of statistics and their use and abuse.

B. State and Local Government Organization

I. Introduction

This activity is to introduce any junior or senior high school student to state and local governmental structure. As a result, the student should know where to go in his local or state government to deal with a water pollution problem. Students will probably develop a schematic diagram to display the governmental breakdown. This activity may be done by any student above the 7th grade.

II. Questions

1. After arriving at a site of water pollution, ask the following questions to lead to the activity:
   a. Do you see anything at this site which is an indication of water pollution?
   b. What are some possible sources?
2. Initiate the activity by asking:
   a. What do you think we as a group can do to stop this?
   b. Do you know the legal restrictions concerning water pollution?
   c. Where would you find them?
3. Continue the activity with:
   a. Are you able to correlate the information you have found?
   b. How could you resolve the problem of organizing the information?
   c. Would a visual aid be more feasible for total group comprehension?
4. Questions which help the teacher evaluate the students' efforts:
   a. What initiative do the students show in responding?
   b. How do they perform as a group and as individuals?
   c. Does the schematic accomplish your objective?

III. Equipment

1. Use of school library
2. Pamphlets released by Legislative Services, Comptroller's Office, and Water Pollution Board
3. Poster board, pens, magic markers, and rulers

IV. Procedure

1. The students should be taken to one site and exposed to a particular pollution problem. The local area should be scanned beforehand for various pollution offenders along bodies of water. The school itself determines whether the students can find the necessary source material themselves or whether these need to be placed in the library prior to the time of the activity. Such things as proximity to state agencies and class schedules will help in determining which course of action should be taken.

2. Either through use of the library or student investigation, the students will obtain information concerning state laws and state agencies. Hopefully, their research will lead to questions dealing with the water pollution aspect. They will discover the necessity of understanding a relationship between the various state agencies in order to deal with them more effectively. At this point, the teacher may suggest a schematic diagram for student use.

3. Students may show interests in other aspects; this should be encouraged. The following areas may be used for future activities or the students may wish to work in groups on some or all of them:

    a. Relationship of federal and local agencies
    b. Operative efficiency of state commissions
    c. Reorganization plan development for a more efficient state organization
    d. State, federal, and local laws dealing with pollution
    e. Biological studies of pollution
    f. Social aspects

V. Past Studies

Students and teachers at the Tilton School Water Pollution Program made such a study during the summer of 1970. They visited the state capitol at Concord, N. H., and obtained information from the General Court Manual and from antiquated schematic diagrams. After visiting many governmental departments, they settled upon the basic agencies which could be helpful.

The students conducted interviews with the comptroller to find where the money came from and how it was spent on the state and local levels. Then they made a schematic diagram of the government organization and a second and more technical one of the water pollution department.

Presented with a hypothetical problem that involved working through the government, the students showed greater interest and ability to analyze because of their increased grasp of the governmental organization. Figures 4B-1 through 4B-3 show the results of the study by a 9th grader.

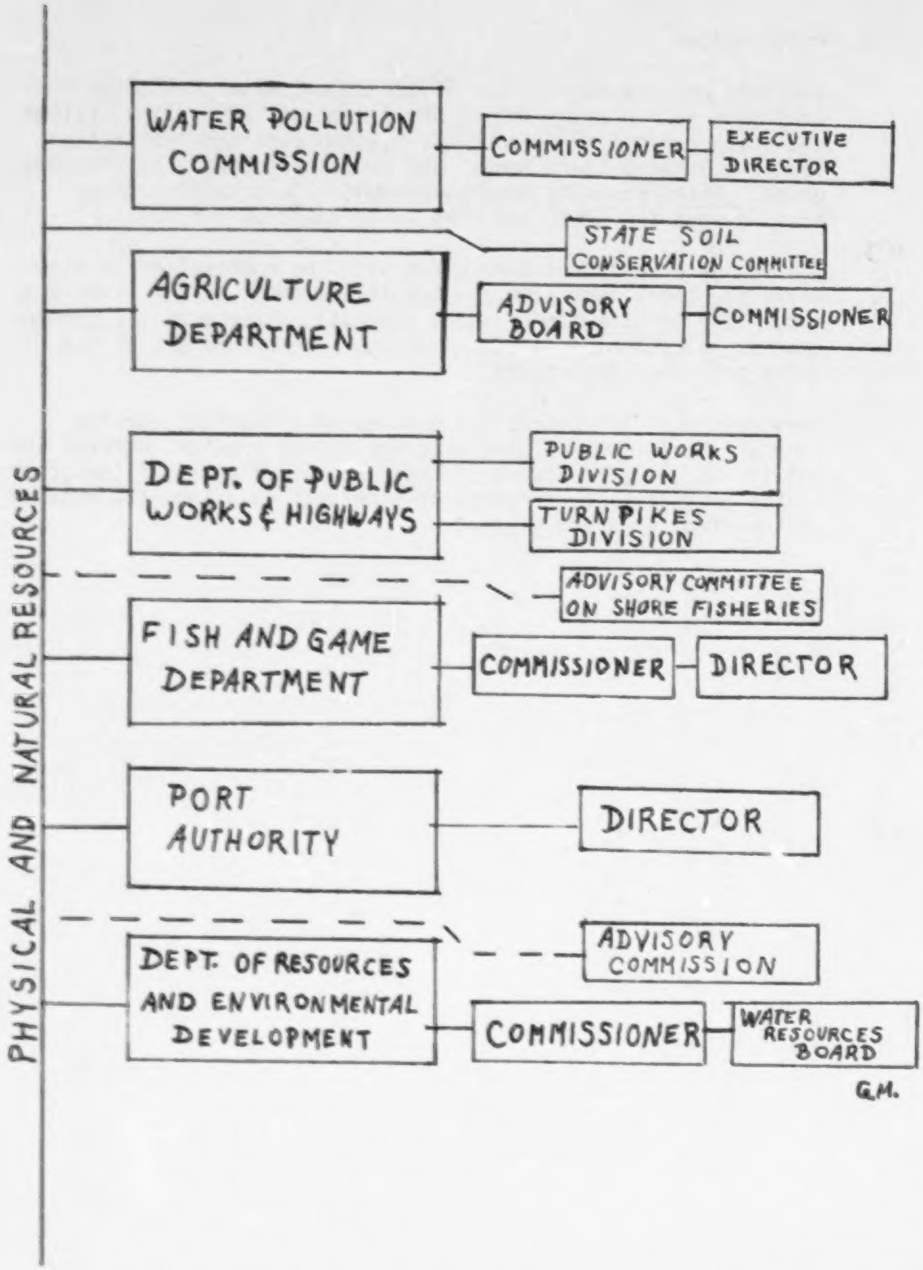

PHYSICAL AND NATURAL RESOURCES
WATER POLLUTION COMMISSION
COMMISSIONER
EXECUTIVE DIRECTOR
STATE SOIL CONSERVATION COMMITTEE
AGRICULTURE DEPARTMENT
ADVISORY BOARD
COMMISSIONER
DEPT. OF PUBLIC WORKS & HIGHWAYS
PUBLIC WORKS DIVISION
TURNPIKES DIVISION
ADVISORY COMMITTEE ON SHORE FISHERIES
FISH AND GAME DEPARTMENT
COMMISSIONER
DIRECTOR
PORT AUTHORITY
DIRECTOR
ADVISORY COMMISSION
DEPT. OF RESOURCES AND ENVIRONMENTAL DEVELOPMENT
COMMISSIONER
WATER RESOURCES BOARD
G.M.

Figure 4B-1

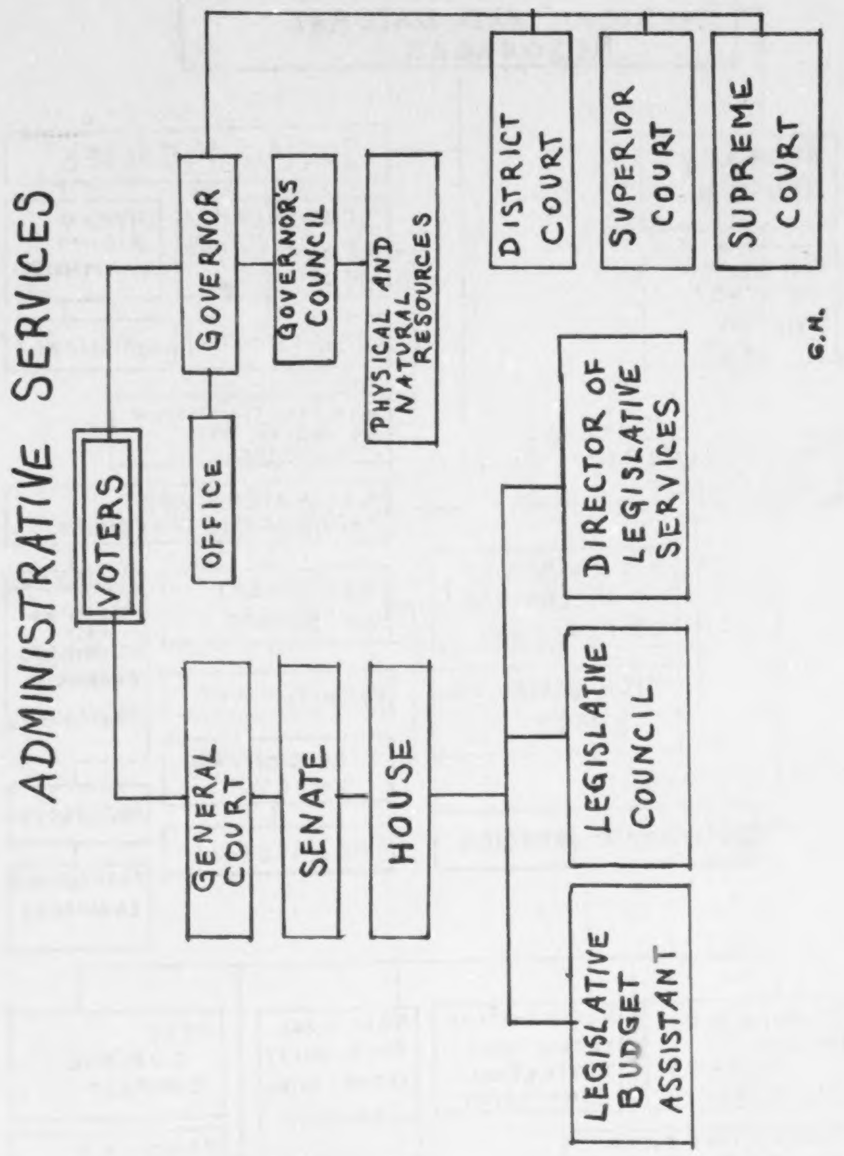

ADMINISTRATIVE SERVICES
VOTERS
GOVERNOR
OFFICE
GOVERNOR'S COUNCIL
PHYSICAL AND NATURAL RESOURCES
DISTRICT COURT
SUPERIOR COURT
SUPREME COURT
GENERAL COURT
SENATE
HOUSE
DIRECTOR OF LEGISLATIVE SERVICES
LEGISLATIVE COUNCIL
LEGISLATIVE BUDGET ASSISTANT
G.H.

Figure 4B-2

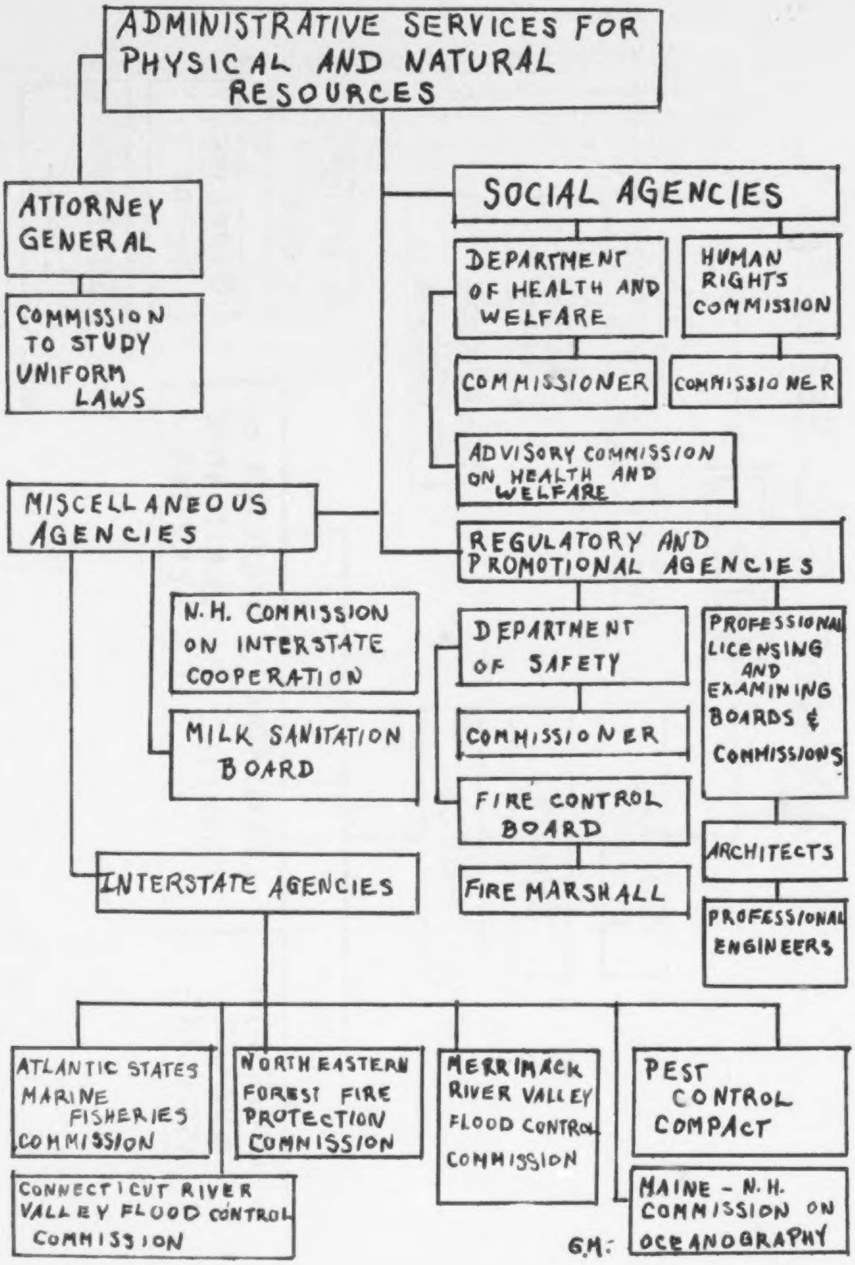

ADMINISTRATIVE SERVICES FOR PHYSICAL AND NATURAL RESOURCES
ATTORNEY GENERAL
COMMISSION TO STUDY UNIFORM LAWS
SOCIAL AGENCIES
DEPARTMENT OF HEALTH AND WELFARE
HUMAN RIGHTS COMMISSION
COMMISSIONER
COMMISSIONER
ADVISORY COMMISSION ON HEALTH AND WELFARE
MISCELLANEOUS AGENCIES
REGULATORY AND PROMOTIONAL AGENCIES
N.H. COMMISSION ON INTERSTATE COOPERATION
MILK SANITATION BOARD
DEPARTMENT OF SAFETY
COMMISSIONER
FIRE CONTROL BOARD
FIRE MARSHALL
PROFESSIONAL LICENSING AND EXAMINING BOARDS & COMMISSIONS
ARCHITECTS
PROFESSIONAL ENGINEERS
INTERSTATE AGENCIES
ATLANTIC STATES MARINE FISHERIES COMMISSION
NORTHEASTERN FOREST FIRE PROTECTION COMMISSION
MERRIMACK RIVER VALLEY FLOOD CONTROL COMMISSION
PEST CONTROL COMPACT
CONNECTICUT RIVER VALLEY FLOOD CONTROL COMMISSION
MAINE - N.H. COMMISSION ON OCEANOGRAPHY
G.M.

Figure 4B-3

VI. Limitations

This activity could vary from an hour to several days, according to the students' desire to delve into such a project. If the instructor gathers certain information ahead of time, it is possible to work within normal class periods. If the state capitol is far away transportation could be a problem for those wishing to visit.

VII. Bibliography

Pamphlets published by the state, or local governments are useful. New Hampshire publishes through the Department of State, _A Manual for the General Court_. Any reports by temporary advisory commissions are also valuable.

C. State Government Model

I. Introduction

This is an activity for the high school level which could follow one in which the state government structure in the area of water pollution has been studied (such as Activity B, in this chapter). It is assumed that the students have been impressed with the complexity of governmental operations; the duplication of efforts; the inefficiencies of the various bureaus, commissions, boards, etc. It is, therefore, anticipated that the students might wish to develop their own organizational plan for water pollution control. The students may then wish to make suggestions to their legislators or to special appointed task forces so that the immediate serious problems might be solved by minimizing the usual red tape and delays.

II. Questions

1. Lead to the activity by asking:
   a. Why does it take so long to get things done?
   b. Why is it so hard to get questions answered?
   c. Are you surprised by the complexity of the structure of the state government?
   d. Do you think the present one can operate efficiently and effectively?
   e. Do you notice that various aspects of the water pollution program come under different agencies?
2. Initiate the activity with questions such as:
   a. Can you name all the people and organizations that might be concerned with water pollution?
   b. Do you think that certain areas are not covered?
   c. Do you think that efforts are being duplicated?
   d. Do you think that you can come up with a better type of organization?
   e. What are some desirable changes that are in order?
   f. How do you think that the changes can be brought about?

3. Continue the activity by asking:
    a. Now that you have developed a plan which you think is more efficient and effective, do you wish to pass this on to your legislators?
    b. Can you name some other individuals and organizations that might be interested in your plan?
    c. If no party or parties show any interest in your plan, do you wish to revise or alter the plan?
4. Evaluate the students' efforts with questions such as:
    a. Did this activity interest the students?
    b. Did they wish to extend the study?
    c. Did they really feel that they were making a contribution to the solution of the problem?

III. Equipment

No equipment is needed. Various booklets on the structure of state governments - from the state in which the school is located or (if a boarding school) from home states. Typewriters, duplicating, or copying machines are in order.

IV. Procedure

1. After students have expressed their dissatisfaction with the present system of water pollution control, suggest (or have the students suggest) that they develop a better system which would more efficiently coordinate all the agencies, commissions, etc.
2. Have the students block out a table of organization.
3. Compare the students' plan with the one proposed by their state.
4. Suggest follow-up by writing letters and enclosing the plan to legislators and others who might be interested.
5. Students may be encouraged to make charts and posters explaining what they hope to accomplish.

V. Previous Studies

1. Studies of government structure in other courses might have given the students an idea of the complexity of government structure.
2. Experiences in the past in seeking out information, such as letter writing and interviewing,might give clues to the problems involved.
3. Some students may have experienced the feeling of powerlessness, the credibility gap, and the great difficulty in getting direct answers to questions.
4. The bibliography contains a list of documents acquired in two days at Concord, N. H. Three tries were required to obtain the table of organization and it was three years old.

VI. Limitations

The only limitation is time. Depending on the type of course that is being offered, this activity can be as short or as long as desired, provided that the interest is there. It is possible to go on to another unit while replies to letters or any follow-up studies are underway.

VII. Bibliography

State of New Hampshire Citizens' Task Force: 1. Over-all Report; 2. Reports of the Consultant; and 3. Reports of the Subcommittees.

"State of New Hampshire Citizens' Task Force Chart of the Reorganization of the Executive Department," Concord Daily Monitor, January 7, 1970.

State of New Hampshire, "Table of Organization of the State Government."

State of New Hampshire, "Table of Organization of the Water Supply and Pollution Control Commission."

Similar reports should be available from all state and regional governments.

D. Anti-pollution Laws

I. Introduction

This activity is designed to determine what circumstances in a given area allow cases of obvious pollution to continue. While it is true that the time gap between creation and enforcement of laws is one of the primary causes, this is not always the case. If anti-pollution laws do exist, it may be that a gap also exists between what is considered to constitute pollution and what legally constitutes a case of pollution. In other words, both legal and illegal polluters have been found to exist.

In order to make such determinations, the students are required to wade through many legal documents as well as carry out interviews. Therefore this activity is suggested for senior high school students.

II. Questions

1. Lead to the activity by asking:
   a. Why isn't something being done about citing a local polluter?
   b. How can you determine the legal status of an industry?
2. To initiate the activity ask:
   a. What agencies (public and private) are directly concerned with industrial pollution in your river basin?
   b. Which ones make the regulations?
   c. What are they?
   d. What people should be contacted for information? Local? State? Federal?
   e. What questions do you want answered? For example, is there a water quality standard in your state?
3. To continue the activity ask:
   a. What types of testing have been done?
   b. Should you make tests of your own?
   c. Who interprets the results of the testing?
   d. What is the mechanism for reporting violations?

e. How do you survey local industry?

f. What steps are being taken toward sewage abatement?

g. Who is responsible for enforcement of water pollution regulations?

4. To evaluate the student consider:

a. What types of background material did the student gather?

b. Were the questions formulated in advance of personal contact with resource people?

c. Was the plan of attack well planned and viable?

d. Can the student differentiate between legal and illegal pollution practices?

e. Is the student aware of public recourse that can be brought against the illegal industrial polluter and the steps in this process?

III. Equipment

No special equipment is required unless the students do testing in the field.

IV. Procedure

1. Select a site of obvious water pollution.

2. Determine the industrial or private persons who are contributing to the pollution.

3. Investigate the local, state, and federal agencies concerned with pollution in your area and determine what laws are now in existence.

4. Select one specific industrial polluter and secure background material on the corporation, i.e.,

a. How is it polluting and to what degree (may be necessary to perform tests)?

b. When did it begin?

c. How many people are employed?

d. What are its gross earnings?

e. What responsibility does it feel it has?

5. If a violation is occuring, discuss the courses of action regarding it. You may want to do one of the following:

   a. Go to the corporation's management and ask about the responsibility to meet legal standards, past actions, and projected activities.

   b. Go to the local politicians about the specific corporation.

   c. Go to the relevant enforcement agencies with your data and attempt to find out what they are doing.

V. Limitations

You may have difficulty arranging interviews. Some people are reluctant to talk freely about the situation. This often includes politicians, factory managers, and heads of agencies on all levels.

Conflicting evidence may occur in the data collected by personal interviews. Biases and backgrounds of the persons being interviewed should be taken into account.

Interpretations of the law may be a problem at times even for the "experts."

If violations are found and reported, don't expect instant action. Legal mechanisms often take a great deal of time.

VI. Past Studies

This activity was carried out by a group of Tilton School students. A small tannery was discovered polluting the Pemigewasset River in Franklin, N. H. Tests above and below the tannery were made to determine the exact nature of the pollution. It was discovered that the tannery was polluting beyond the limits set by the State Water Pollution Control Commission. Although a violation was found to exist, the State allowed this until completion of sewage abatement by the tannery.

VII. Bibliography

Camp, Dresser, and McGee, Report on Sewerage and Sewage Treatment, City of Franklin, N. H., January 1965. This is a consulting engineering firm's report on the treatment of this city's municipal and industrial sewage.

Social and Political Factors

State of New Hampshire, Laws Relating to the Water Supply and Pollution Control Commission, January 1970.

U. S. Department of the Interior, Federal Water Control Administration, Report on the Pollution of the Merrimack River and Certain Tributaries, Part 1. It contains the summary, conclusion, and recommendations for the cleaning of these rivers.

E. An Elementary Investigation of Local Water Anti-Pollution Programs by Interviewing Government Officials

I. Introduction

This activity could be used in classes for 6th through 12th grade students to evaluate the evident effectiveness of the government to deal with water pollution. The students should become aware of and develop an interest in the local problems of their communities.

II. Questions

1. Lead to the activity by asking what are the water pollution problems in our community.
2. Stir interest by asking:
    a. Who are the people responsible for controlling these problems?
    b. Do they use the authority given them effectively?
3. The teacher may evaluate the activity by considering:
    a. What were the students' results?
    b. What reasons were there for these results?
    c. Were the students' questions well prepared?
    d. Was the students' back-up knowledge sufficient?

III. Equipment

None is required.

IV. Procedure

1. Find out a few problems in your community by reading the newspaper.
2. Determine which laws pertain to these problems.
3. Make up an outline of questions.
4. Set up the interview.
5. Record the results and your reactions by writing articles or reports.

V. Past Studies

This outline was followed by 6th grade students for interviews regarding pollution problems in two communities. Problems were encountered in dealing with community officials. The following reaction was written as a result of a 3 day trip to Washington to find out what was going on. The article appeared on pages 75-77 of the March 1970 issue of the Academy Science Journal published by Germantown Academy, Ft. Washington, Pa. The authors were seniors in 1970.

Moving Around on Pollution

"On March 4th, a Wednesday, four leaders of the Wissahickon Lobby met with Professor Zandi of the University of Pennsylvania Ecology Department. The professor is an authority in matters of pollution and its treatments. Another meeting took place on March 6th with Samuel S. Baxter who is the Commissioner of Philadelphia's Water Department. Both interviews were very educational and further indicated the number of highly paid pollution fighters who are sitting around doing nothing.

"Mr. Zandi was very impressed with the enthusiasm of the Wissahickon Lobby; however, he seemed to be very pessimistic as to any positive results. Mr. Zandi suggested some kind of coordinator or advisor who could tie all the loose ends together. It is important to note that Mr. Zandi did not have all our material and therefore could not review the situation to its furtherest point. One must also take into consideration the role of the University which is purely educational. You might call it a noninvolvement policy. Mr. Zandi proposed that he would come to our school once a month and check the project's progress and offer his advice. There was no settlement as to the future; however, Mr. Zandi said he would look into a student advisor on a weekly basis (senior doing graduate work in actual pollution).

"Our interview with Commissioner Baxter dealt more with the legal aspects of pollution. He is presently involved with an article entitled, "Are Things As Bad As They Seem?" Mr. Baxter felt there were many other problems that were more pressing than the problem of pollution. He posed questions such as, "Many people want all the streams and waterways as clean as possible. Can the 4 million people living in metropolitan Philadelphia expect to physically clean up the streams?" Mr. Baxter is in a bind as are all officials handling this problem; however, is this a valid excuse for the hoarding of enthusiasm!

"The shortage of money was brought up by the Commissioner, but how is it that a newly-formed lobby such as ours is capable of raising money, but not a large organization such as the Philadelphia Water Department? It also seems as though the people themselves are aiding the various extents of pollution by rejecting any increase in taxes for the fight against pollution. Many enjoy the reduction in taxes due to the amount paid by the companies who must pay taxes because of the pollutants they feed into the air and the water. It has even been mentioned that various people don't want anything done for that specific reason. I'd say that was a little selfish on the people's end of the pole. Will it take a critical situation to move people, or can we join in and work at it now?

"Mr. Baxter's problem is much more complex than the one we have here at the Wissahickon and this makes ours much easier to clean up. An example would be the storm sewerage problem in the city. After it rains much waste and pollution is carried into the sewers, however, it only amounts to 3% of the Delaware River's pollution. For the city of Philadelphia to clean that 3% up, it would cost approximately $3 billion. In 3 years the Department has spent $75 million on treatment plants. This is all very impressive, but somehow something can be done on the Wissahickon that is not going to cost $75 million. The Wissahickon is no Delaware River; however, if we were situated on the Delaware, the impression that was made by certain figures would have been much less agreeable.

"Our feeling is one of optimism, and the problems of the larger scale pollution fighters do not necessarily involve us. With the number of students we have working on the Lobby and the amount of information we have piled up, one can't help but look at things in a bright light. Things are moving, and the right people (industrial and sewage polluters) are now beginning to worry, is there a better indication?"

Bill McKay '70
Sal Siciliano '70

The following reaction was written as a result of a trip to the capitol of Pennsylvania. It was a research trip for a student lobby. This article appeared in the December 1969 issue of the Academy Science Journal, published by Germantown Academy, Ft. Washington, Pa.

Pollution and the Law

"On November 26, 1969 I traveled to Harrisburg to interview a Mr. Smurda of the Department of Health about water quality. My reason was to gather legal data on the relation between water quality and the law. My hope was to find out the different legal ways in which to help my school in its attempt to unpollute the Wissahickon Creek. As my interview went on I was increasingly impressed that though there are laws, there is no real way to stop filth from being poured into our streams unless the companies decide to do something on their own.

"The first thing which I was shown, was a copy of the laws as they now stand. I immediately turned to the page which told of the penalties for constant waste disposal into streams and found the following:

> 'Any person who shall continue to discharge sewage or permit the same flow into the waters of the Commonwealth, contrary to the preceeding provisions of this act, or after the expiration of the time fixed in any notice from the board to discontinue an existing discharge of sewage into the waters of the Commonwealth shall, upon conviction thereof in a summary proceeding, be sentenced to pay a fine of not less than twenty-five dollars and not exceeding one hundred dollars for each offence, and a further fine of ten dollars a day for each day the offense is maintained and, in default of the payment of such fines and costs, the person or the member or members of any association or co-partnership, or the officer or officers of any corporation, responsible for violation of this act, shall be imprisoned in the county jail one day for each dollar of fine and costs unpaid.'

"The part of this which is most distressing is the fact that a simple appeal can delay indefinitely the payment of fines which might even reach a meaningful size in the area of $10,000 or more.

"For the most part the rest of the articles which I was shown offered little that those people at my school did not already know. All the figures that I saw agreed with our own and showed that many levels including the total soluble phosphate level is 500% (approx.) higher than it should be.

"The one thing that I think really struck me was that the State knows who is polluting the creek and even goes to the trouble of listing who these people are. This was the list as taken from the implementation plan for interstate waters Schuykill River basin.

> Industrial Wastes-Discharges -- Nicolet Industries, Certainteed, Lansdale Tube-Philco, Merck, Sharp & Dohme, Precision Tube, Leeds and Northrup, Philco-Ford TV, McNiel Labs.
> Sewage -- Ambler MSS, Ambler South MS, North Wales MSS, Abington T. MSA, Gwynedd Jr. College, Silverstream Nursing Home, Delaware Valley Independent Sewage, Selas Corp., Aidenn Lair, Upper Gwynedd T. MSA, Sheraton Motor Inn.

Social and Political Factors

"The most distressing thing is that the State knows who is throwing things into our creek, yet they can do very little. Something must be done within the near future, and it must be done by the people involved. If reform cannot come fast enough from the Government, cooperation must come from all involved."

Nick Backrack '70

The following article appeared in the February 1970 issue of the Academy Science Journal, published by Germantown Academy, Ft. Washington, Pa. The author was in the class of 1970.

Washington Excursion

"This was the first trip to Washington concerning Federal anti-pollution laws and programs. We entered Washington with a naive attitude that people would be eager and willing to help us, but when we left we realized the problems that confront an anti-pollution program.

"The first obstacle to overcome is getting an appointment. Time can be lost if this is not done before arriving in Washington. We lost one afternoon of work because we did not have a definite appointment. A definite time and day will resolve this problem.

"Another problem we incurred was that we can be given the run-around quite easily. To solve this problem we need somebody, inside Washington, or out, who is able by his name to get us action. At this point, only a few people seem interested in what we have to say. The only two places were we found any interest were Mr. Cutler of Senator Muskie's staff and Representative Coughlin's office. In both these places, we found people willing to listen and talk with us. Mr. Cutler was helpful by naming other people we could contact for help. These were Thomas Jarling, Minority Counselor Public Works; James Smith, the Conservation Foundation, Washington; the League of Women Voters; and the Administration.

"We should not, however, look to Washington as our sole means of help. Although help from Washington is nice, we must start looking around us for help because this is where we can apply the most pressure. We should look for a group to help us. If there is none, we should form one. This can be done in several ways. One way, that Mr. Cutler agreed with, was an association. This association would be made of schools from throughout the Delaware Valley. With business and community backing, we can use this group to get things done as well as applying pressure. We can also join lobbies in both Harrisburg and Washington. Being part of a lobby will also open doors and bring us more power.

"Mr. Cutler also stated that unless the waters we are investigating are interstate, we must work within State and local laws. If the waters are interstate, then it comes under Federal jurisdiction.

"Although the trip was not a complete success, we did learn something. The next group that goes down must be ready beforehand. It must have specific questions to ask and definite appointments. Members must be ready to be given some run-around, but also they should realize it and try to stop it. We must also get contacts in Washington who can help us get appointments in Washington."

Pieter Platten '70

VI. Limitations

In some large cities, there might be a problem in getting an interview. And, many times one official will refer you to another, which makes things difficult for reasons of transportation and time.

VII. Bibliography

English teachers generally can provide a bibliography which gives references on writing reaction papers.

F. Publication of a Science Journal

I. Introduction

This activity introduced the student to the communications aspect of pollution studies -- a science journal as one key to reaching other people through students' activities. This project would involve more than science; the English, history, and art departments are important contributors to the overall results. The student is eager to share his enthusiasm and ideas with others; the result is a spreading involvement in pollution activities. Grades 7 through 12 will find this a good activity. In one case, a second grade remedial reading class made a significant contribution to one science journal.

II. Questions

1. Ask students if they feel a need exists for communication concerning pollution.
2. Initiate the activity by asking the students what method they consider most appropriate for the establishment of communication and whether or not a science journal would help in creating an awareness of the problem.
3. Continue the activity by asking to what activities the establishment of a journal could lead.
4. Evaluate the activity by determining:
    a. Are students interested in participating in some way in the journal's production?
    b. Are they concerned about communicating their ideas with others?

III. Equipment

Equipment requirements vary according to resources available. Your journal could be a mimeographed series of reports stapled together or a sophisticated, printed manual. You will need paper, typewriters, mimeograph, stamps, and envelopes for mailing, and people to work.

IV. Procedure

Suggest to students that they write up their various activities and collate them into a booklet. Devise a method to choose 8 or 9 students who will be in charge of general production such as reader service, editing and correcting articles, and collating material. A suggested mailing list would be the area independent and public schools. This type of activity allows students of all age to participate. Perhaps, if you have the time and the materials, you can print copies for parents and alumni to generate interest. Encourage every student to contribute, not necessarily scientific articles, but ones dealing with pollution in general.

V. Past Studies

Germantown Academy, Ft. Washington, Pa., last year started production on the Academy Science Journal. Nine students from the Biology 2 section were in charge of general production, and the first articles were contributed by the biology, physics, and chemistry departments. However, after a couple of issues, students nonscientifically oriented were contributing write-ups on projects and activities, varying from the invention of a flow meter to 1st grade essays on the meaning of pollution. Artistic students contributed diagrams, drawings, and cartoons. The Journal's content increased in size slowly, but the variety of the content broadened considerably. Eventually the journal was sold for 25¢ each to members of the local Watershed Association to raise money for some projects. The students in grades 1 - 5 were so enthused that they made and sold a booklet of drawings and essays on pollution. The money they raised was used to buy a filter for the school incinerator. The Academy Science Journal is printed monthly and contains 80 typewritten pages. It is distributed free of charge to approximately 200 schools. The purpose of the Academy Science Journal as stated on the title page is:

> "As faculty of the science department of Germantown Academy, we uphold the belief that many of our students are capable of making significant scientific contributions at the secondary level. These students possess the initiative and scientific curiosity to determine problems, conduct research, and translate the information into meaningful conclusions.
>
> "We feel that their investigations warrant publication in order that others may share in their activities."

VII. Bibliography

Science journals on any level are the best bibliography. Check with your school librarian.

G. Orientation Program For the Study of Water Pollution

I. Introduction

This activity is set up as a discussion for a group orientation study of water pollution. The group can be a traditional class. It could also be a community group (e.g., students from several high schools that do not offer a course in water pollution). The questions should stimulate the group into shaping a skeleton from which the leader can plan a study agreeable to all. It would be helpful to get through the whole activity in one session. However, the rate of progression must be determined by the group. Tape recording the discussion would have value; the group leader could use it as a reference in the future. The questions are set up under the precept that the group will be situated by a polluted body of water. Perhaps it will be the one the group decides to study. This natural setting should act as a motivating device, as seeing the problem would increase awareness and hopefully concern among the group.

II. Questions

These questions are to provide thought-provoking topics for discussion. The first three sections play a specific role in the progression of the orientation.

1. To lead into the activity - these questions are to "set the stage," to lead the group to concentrate on water pollution. They lead into the real investigation.

   a. What is pollution?

   b. Can you identify by sight any pollution in this water?

   c. Are natural things like leaves and twigs pollution?

   d. How is a scientific approach to the problem relevant?

   e. What can science tell us about the problem?

   f. Can this information help us to solve the problem?

   g. How can data and facts help us?

   h. Why is a social approach important?

   i. How can a social approach help to solve the problem?

   j. How can public relations help with a commercial approach to fighting pollution?

k. On which commercial enterprises should attention be focused?

l. What type of public relations is important?

m. Reflecting recent months, pollution plays an important role in politics. How can politics influence pollution?

n. How can his outlook on pollution affect the fate of a politician?

2. To initiate the activity - the trend should be set in a meaningful direction at this point. Discussion now centers about the objectives of the group. These shall be recognized by covering the points to each numbered theme question.

a. Should we study a specific body of water?

b. What would you like to find out about the pollution of this water?

-chemical

-bacterial

-historical

-aquatic life

-public influence

c. Are we going to try to solve the pollution problem?

-(apply what was discussed in A)

-when

d. How shall we divide the group, if at all?

-scientific

-social

-commercial

-legislative

-political

e. Whom shall we involve in fighting this pollution?

   - -peers
   - -family
   - -community

f. What type of information shall we request, and what commercial enterprises shall we contact?

   - -only water polluters
   - -any polluters
   - -research agencies
   - -factories
   - -small enterprises

g. What information shall we seek?

   - -history
   - -general information
   - -a role we can assume now

h. What shall our group objective be?

   - -(tie together what was discussed)

3. To continue the activity - now that the atmosphere is set and the group objectives outlined, these questions focus on planning the group's activities. The extent of the use of the questions will vary, especially in the case of high school students. Many will have to have been answered by other than the group in preparation of a type of contract, be it a community group.

   a. Where shall we begin?

      - -introduce limitations set by authorities, if it is necessary
      - -frequency of group sessions
      - -summarize B and make it concrete

-independent work

-funding

-publicity

4. To evaluate the students' performance - these questions can be applied to a classroom situation if the need for an evaluation persists. If it is a community group, this evaluation may be unnecessary. The leader will have to evaluate a group of high school students if their schools request it. Evaluation may also be necessary if credit is to be given for the study.

    a. Did the group member help set a meaningful trend to the discussion?

    b. Did he (she) make specific personal objectives of the study?

    c. Did he (she) help with the setting of the group objective?

    d. Did he (she) introduce relevant discussion matters not included in the outline?

III. Equipment

The equipment used should be decided by the leader. Some may prefer to keep the whole orientation a discussion. Others may find nonscientific aids helpful. Listed below are a few suggestions:

1. Should the students desire to observe the water more closely, the following supplies may prove useful:

-bucket

-rope

-hand lens

-old cloth (as a net)

-tin cans

-plastic bags

-jars or bottles

2. Current mass media about pollution may prove helpful through the orientation.

IV. Procedure

Begin the orientation with questions. Although they need not be carried out exactly, the questions are prepared to facilitate discussion of relevant matter. The leader must "play it by ear" as each group will be directed differently.

V. Past Studies

1. A discussion held in the natural setting has proved effective at Grymes Memorial School, Orange, Va.
2. The role play technique has been used with great success at Nottingham Academy in Buffalo, N. Y. Its use fosters understanding of various situations and opinions among students. It is a technique especially good for a student who refuses to try to understand a situation.
3. It is important that the students have an understanding of the pollution problem. A raw scientific approach without any orientation is more apt to "fail" than a study where the students actually understand the significance of any scientific methods before they begin.
4. Notice the work "leader" is substituted for teacher. A study of water pollution is something new and different to most students. It is more important to learn about it than be taught about it. However, the need for an experienced moderator still exists. This person may or may not be a "teacher." Hopefully, the teamwork that should result will put all group members on the same level, regardless of their age.
5. Role playing activities:

   a. A constant consumer of high phosphate detergents argue about detergents. (If others are introduced, the argument should become a discussion.)

      (1) High-phosphate-detergent consumer

         -if phosphates are that bad, the government should outlaw their use

         -the laundry must be clean, and there are no comparable substitutes

-phosphates tend to make the water 'wetter', and this especially is necessary in hard water areas

-I have to use up the detergents I've already purchased.

(2) Anti-pollution-conscious consumer

-phosphates are a main contributor to algae growth and increased bacteria growth, thus causing eutrophication.

-it is up to each individual to fight pollution to the best of his ability.

-which do you value more - clean clothes or clean water?

-if we do not purchase them, store owners and manufacturers will be forced to act quicker.

(3) Detergent manufacturer

-research has been going on for many years.

-automatically banning phosphate detergents would present serious problems.

-housewives like modern detergents and will not settle for soap.

-if housewives were really so antipollution, why are they still buying high phosphate detergents?

(4) Grocery store owner

-must stock all different products so a consumer may purchase according to individual choice.

-obligation to provide an outlet for manufactured products.

-must not let viewpoint overpower the wants of consumers.

-competitive reasons force me to stock favorite laundry aids.

b. A purchaser of brightly-colored tissue products which contain nonbiodegradable dyes is angry because the store she patronizes stocks only white tissue now. This is a discussion among any number of the four or more possible role players.

(1) Angry purchaser

-these products brighten up the bathroom decor.

-if they are banned, so should other luxury items that pollute worse.

-these products are much softer.

-somebody has to buy them.

(2) Anti-pollution crusader

-unnecessary pollution created.

-white tissue products do the job just as well.

-individuals should fight pollution to the best of their ability.

-such products are a waste of money.

(3) Manufacturer

-color is a way of brightening life.

-nobody is obliged to buy them.

-dye pollution from fabric mills, etc. is worse.

-manufacturing not stopped for economic reasons.

(4) Store owner

-color discretion is not right.

-comparable products that pollute less are still stocked.

-unsightly dye pollution is created in manufacturing - let us stop as much as we can.

-convince manufacturers such products are unnecessary luxuries.

c. A boatowner is upset with the new law concerning watercraft sewage disposal. He discusses it with a friend.

(1) The Law

-illegal to discharge sewage from watercraft into water.

-head may be sealed permanently and still comply with the law.

-all users of the state's waterways must comply.

(2) Boatowner

-silly law to bring sewage back to land where it will receive inadequate or no treatment.

-pollution control device is too expensive for the seldom-used head.

-out-of-state boaters are being cheated.

(3) Anti-pollution crusader

-better to have sewage concentrated than discharged throughout the waterways.

-other states will be encouraged to form better standards.

-obligation of all boaters to comply.

d. The role plays should then be analyzed:

-did the person play his role all the way through?

-could a concensus be attained?

-were any dependencies among various roles cited?

-were resolutions suggested; could they be suggested?

VI. Limitations

1. In a community group, the problem might arise if participants are not acquainted. The leader must be prepared to help resolve this problem, as a study of water pollution requires real teamwork. The discussion approach which this particular paper deals with should help overcome this obstacle a bit.

2. Students may have trouble understanding problems of fighting pollution. It is important that they understand the viewpoints of those involved as professionals. This is an area where they assume the role of a designated position. In a given situation they are to work out a problem verbally, trying to adhere to their role under group obervation. It is interesting and often advantageous to have the students exchange roles about halfway through. The examples below are representative of typical problems encountered in an effort to fight pollution. They are accompanied by points that often occur in the situation. There are undoubtedly supplements. The points given are not paralleled.

VII. Bibliography

This paper was put together by drawing on experiences. No specific references were consulted. To initiate and sustain an activity such as this, the best resources are current mass media.

H. An Anti-pollution Club

I. Introduction

This activity is designed for high school students who are interested in starting a club dealing with different facets of pollution.

II. Questions

1. Lead to the activity by asking:
    a. What problems of pollution in your area would you like to see remedied?
    b. How could student action help resolve that solution?
2. Initiate the activity with questions such as:
    a. What specific aspect of possible action would students be most interested in?
    b. What type of student or school organization would be most effective and useful to enable students with their crusade?
    c. What angle of consideration of this aspect would be most effective in dealing with the problem?
3. Continue the activity with:
    a. Could an outside institution help the organization in any way?
    b. Could increased publicity further spur or expand the program?
    c. Have all of the facets (i.e., side effects, sources, relationship to the total pollution scope, consequences, etc.) been dealt with?
    d. Are there any similar problems in the area?
    e. Are there any other schools or organizations that might need help or could benefit from your organization's experiences?
4. Consider evaluating students with questions such as:
    a. What did your group accomplish?

b. How did the results, conclusions, or experiences compare with those anticipated?

c. How could the plan be improved?

III. Equipment

The equipment required will be determined by the activities of the club.

IV. Method

The method for starting an organization will vary depending on the school itself and the kind of program desired. Students interested in the numerous aspects of pollution (i.e., science, legislation, philosophy, etc.) should be encouraged to participate because differing skills are needed in any project. If the students show an interest in establishing a club or similar student organization, help them out by:

1. Finding out the procedures for establishing a club.
2. Defining the purpose of the club (write a charter).
3. Publicizing the club.

In defining purpose, the activities that the club hopes to carry out or the possible lines of action should be considered.

After the club has been functioning for a length of time, it might be advisable to sit down as a group and list or outline the activities the group has engaged in. This outline should include the failures as well as the successes. From this outline, a short explanatory program of what the club is doing could be evolved very easily.

The program could utilize any posters and/or charts and anything else that the club has produced to explain and exemplify pollution.

A 10 to 30-minute slide program with a narrator and sufficient subject matter can be very effective. It could be presented to students in other schools to encourage them to form their own club.

V. Club functions

1. Cleanup of polluted areas.

Organize a basic plan for the cleanup of community rivers, streams, and highways. Make use of volunteer community citizens. Review the sites to get an idea of how and what to clean up. Needed materials could include trash containers, vehicles for pick-up, and transportation. It is recommended that plastic or canvas bags be used for waste instead of paper bags.

2. Underground newspapers.

Underground newspapers are effective tools for the students to work with because they are not limited by the censorship of the administration. Organizing a paper that will be published regularly is a Herculean task. As the group starts work they have to raise money for supplies and decide on the purpose and format of the paper. Usually money can be obtained by soliciting students and organizations. Some problems are: interest has to be maintained; the paper has to eventually pay for itself; and the staff should be organized and committed.

3. Distribution centers (books).

As club activity, a booth can be set up and operated by the students to sell or distribute material concerning pollution. Buttons, posters, and stickers can be made by the students and sold for a profit. A number of "important" students can be selected to receive these materials free, in order to stimulate interest. Material which could be distributed could include pamphlets on water and other kinds of pollution which are free upon request from the Federal government; the Congressional Record which is informative; and school newspapers concerned with pollution subjects. This keeps a constantly changing pile of materials at the booth.

4. Erosion.

Find an erosion problem in your community that needs attention. Determine what would be involved to correct the problem. If it is a major undertaking, seek the help of the community. If it is a small project, gather the needed equipment and materials and set up a work day for the club and other interested students.

5. Colleges and Elementary Schools.

Contact colleges in the area to see how a cooperative (i.e., sharing data equipment, ideas, personnel) can evolve in an academic area. Contact elementary school teachers to see how your club activities can be shared with the younger students.

6. Communication.

Communication has an important role in any activity as it is necessary to make information public so that it can be an effective force in the school and community. The methods of communication available are unlimited. Inside the school, use the school newspaper or the distribution of dittoed sheets at information centers. Outside of the school the students could set up an underground newspaper and talk to the local radio stations and newspapers about time and space to discuss their activity.

7. Poster and Art Exhibits.

For any art exhibits, proper hanging space must be available. There are several exhibits made-up for exhibition in schools; one is available from Eastman Kodak Company. These exhibits are of photographs taken by students and judged by professionals, and rated 1st, 2nd, or 3rd. You can find out about these exhibits by asking the local Kodak shop; for other exhibits ask a local museum.

Poster contests can be sponsored in your school by the art or the science department. All you need to do is to arouse enough enthusiasm for the project so that you have enough contestants. One idea for promoting the enthusiasm is to make materials available to the students. Often, when some kind of prize is offered, more of the older students will participate. Otherwise, your best participants will be the students in the lower grades.

Having any kind of exhibit in the halls of a school building will help in bringing the students together. You will find a contest motivates some students who would not have been motivated otherwise.

8. Field Trips.

Field trips are interesting and useful to a club. But trips should be to areas of interest and have relevancy such as areas of established pollution. The date, time, and methods of transportation should be set up before the designated time. It is possible to get help or maybe permission from authorities if you write ahead of time or call to ask.

The purpose of the trip, either testing or knowledge-seeking, can be discussed beforehand to look for key points during the trip. In the case of testing water, legal complications should be taken into consideration.

VI. Past Studies.

1. A group of high school students in St. Louis (University City High School) set up a political newspaper, which helped to initiate some changes within the school structure.

   Limitation: Initial costs and motivation of students to 'stick it out'.

2. State-wide cleanup of streams, river, and highways in Vermont.

   All communities were asked to help. General agreement for future involvement evolved. People became aware of the pollution problem and worked for a common goal.

3. Paper drive by students of the Vermont Academy which was publicized beforehand for people to call in and ask for pick-ups. The paper was sold to a factory that reuses it.

4. In North Quincy, Mass., students volunteered to help beautify a mental retardation center. Donations were given by local florists and American Legion Post. Other students from different schools also helped.

   Limitations: Follow up is necessary to care for plants (project was stopped by school closing).

5. At Germantown Academy, a group of 40 to 50 students was formed to lobby the Pennsylvania State Legislature. Students soon found out that they could not be effective unless they had the facts. Several subcommittees were formed to look into the interaction of Federal agencies, state agencies, and local authorities. Further interest developed in writing the history (economic and social) of each polluter in the watershed. For this activity small groups of 2 and 3 investigated the corporations by consulting the Sanitary Water Board's health violation records, interviewing corporation executives and engineers, and reading annual reports and other public relations material. The resulting write-ups and block diagrams were circulated among all lobby members. Letters were written to legislators and their reactions noted in the Academy Science Journal. As a by-product of the investigations and letters, the school now receives 2 copies of the Congressional Record, White House press releases on ecology and pollution, and Federal legislation documentation (public laws). Many of the students reacted by showing deep interest in working within the system to accomplish anti-pollution programs. The material they had studied in history, they acknowledged, was an important part of their background which they had not realized before.

VII. Limitations

Often financing a club is difficult. Selling buttons and stickers is a good way to raise quick money; but some projects are expensive and donations must be sought from local lumber companies, manufacturers, furniture companies, florists, chemical plants, scientific, electronic firms, and even the Army Reserve.

It is important to maintain the program after it is once started. Make sure that you are not doing too many things at once; if some activities begin to fade due to the lack of manpower, try to interest the students in joining the more active project. Change the pace occasionally with non-related money-raising projects, such as a car wash. Be sure that your activities are varied. There should be at least one major action program in operation. Be sure to inject new ideas as the old activities are resolved.

Occasionally a school administration does not endorse student programs which it feels are destructive to the normal school routine. You might overcome this if you can get the administration not only to attend the meetings, but also to participate in the projects. It will help build a closer relationship.

Sometimes transportation, as well as distance, is a factor. Make sure vehicles are available, that time is available to complete the project.

If space is a limiting factor, make use of homerooms, study halls, etc.

VIII. Bibliography and References on Community Action Groups

Hall, D. M., Dynamics of Group Action, The Interstate Printers and Publishers, Inc., Danville, Ill., 1964. This is a handbook on group behavior. If you are originating a club or group, you will be interested in the problems of establishing goals and objectives. It will help you to understand the how, why, who, when, what, and where. It will give you a background in both the theory and practice of group work.

Mann, John, Changing Human Behavior, Charles Scribner's Sons, New York City, 1965. This book illustrates the problems created by advance technology. In order to survive, we must change. The author gives the reader a background in significant attempts to assess the effectiveness of currently-used behavioral change procedures. Chapter 7 is especially good in the following areas; the effect of group size, composition of groups, group power structure, the effects of group discussion, the effects of group interaction, the influence of objective feedback, principles of behavior change in the small group, and group dynamics. Chapter 8 deals with effects of mass media and the lab as opposed to the field setting. Chapter 9 concerns attitude changes. Intergroup contact and implications of social action are discussed in Chapter 10.

Martyn, Henry, Roberts Rules of Order, Robert Scott and Foresman, Chicago, Ill., 1915.

Social and Political Factors

I. How to Win Friends from Skeptics, Critics, and Doubtful School Administrators Without Really Trying

I. Introduction

This activity is designed to get students involved in a campaign to elicit interest, help, and support from people in a school system (chiefly administrators) who may not be in sympathy or agreement with the focus on an environmental approach to education. These activities are intended to demonstrate that the cost and public relations aspect may serve to enhance such a program rather than hinder its development.

II. Questions

1. Pose the following questions to the students to initiate or lead into a discussion relating to problems in those schools where a gulf exists between students, teachers, and administrators regarding the implementation of a viable environmental program.

   a. How might a small group of students communicate effectively with their principal, headmaster or similar administrator?

   b. What problems seem to underlie the difficulty (cost, public relations, scheduling)?

   c. What angle of consideration of this particular aspect cited would be most effective in dealing with the specific problem?

   d. How do you think that student action might help solve the problem and what limitations do you anticipate?

III. Equipment

Materials for writing and illustrating should be available to the student as well as certain statistical data relevant to environmental education, books, and newsworthy articles which would assist the student in carrying out this type of activity.

IV. Procedure

The method for seeking assistance and support from school administrators will vary depending upon the inherent problems of that institution and the type of environmental program desired by that school. Those students interested in specific aspects of pollution should be encouraged to take an active role in this activity.

Several procedural approaches are described below. One or more of them may be used as indicated by the problem in the school, perhaps combinations of two or more procedures may be used, or procedures not developed here but devised by the group to fit the particular situation.

1. Use of existing clubs, organizations, or groups.

   Make a checklist of all the extracurricular clubs and organizations in your school and select those groups which would be used to promote the cause of environmental education. Here are a few suggestions.

   a. Art Clubs might be asked to sponsor a photography contest on pollution or pollution sculpture display in the school library. This would bring attention and interest.

   b. Science or Biology Club might be asked to form a splinter group called the Ecology Action Group which could actively campaign for the type of school program desired. They could distribute printed material on the merits of environmental education, generating further interest by use of bulletin board displays, posters, or conducting an all school assembly to "educate" all on the aims and goals of the specific program wanted at their school.

   c. Debating Clubs might devote an entire school term to debating issues related to the pollution problem. School Publications would ideally serve as an effective instrument to disseminate information and keep the community up to date on progress of the "campaign." A special column on Environment in the newspaper, various pictures of worthwhile and pertinent activities accomplished by the school's participants could add much to the overall support of such an endeavor.

2. Large Group Activity.

   a. There is no better way to impress people of the significance of a particular need than the large group activity to improve or call attention to something.

   b. Those students most interested or skilled in matters of organization might like to coordinate an all campus or all school cleanup. This would require committees to handle such areas as publicity, manpower, collection, sites, and disposal.

   c. A clean-up activity might be followed in a month or two by a beautification project undertaken by a smaller group or groups. The local newspaper could be called in to help the cause by a well-placed feature article employing several pictures.

3. Improvisation of Equipment.

Since the cost of any program is a main obstacle to overcome in the eyes of an administrator, those activities which show how experiments may be done at minimal expense are important. Students who are familiar with certain procedural techniques described in the guide should be asked to demonstrate how alternate methods may be used. Drawing from examples in the Bacteriology of Water section and the Hydrologic Cycle part, substitutions of more sophisticated equipment may be shown.

4. Public Relations.

   a. Many schools are concerned about their public image. The probability of conflicts and the subsequent loss of prestige make many an administrator hesitant about the school's direction in a full-fledged program of environmental education.

   b. Through the use of questionnaires, students may seek public information about certain issues relating to pollution. For example, sewage treatment in the school's area may be the topic for one questionnaire, or the district water supply may be another timely topic for polled opinion.

   c. Radio programs and P.T.A. discussions by the students might be effective for large-scale communication. Involvement of parents, such as a car pool for necessary transportation, would bring in a very important interest group and, at the same time, create an awareness of the sincere effort by the students in achieving their goals.

   d. A very successful method of arousing public interest is the local newspaper. Students who have had journalistic experience should be encouraged to write weekly articles and to document their news items with actual accounts of student activities which are concerned with the environmental crisis.

V. Past Activities

1. Germantown Academy in Fort Washington, Pa.

Students at this school solicited certain business concerns in their community for help. Financial donations and specific equipment were given in many cases. In others,a cooperative arrangement was worked out whereby the industry provided some service for the school in return for student services. For instance, potato sacks were given to students for use in erosion control. Military surplus was solicited for possible useful materials and equipment.

2. The George School in Newtown, Pa.

   Students at George School made a study of the Neshaminy Watershed. The results were of great public interest in the region and a copy was sent to President Nixon. Response to the study from federal and state officials was great. Such publicity would give impetus to any school program.

3. Mount Hermon and Northfield Schools in Massachusetts.

   Water quality parameters on the Connecticut River were studied in depth by several classes at these schools. Their work received attention from the Connecticut River Watershed Council, and consequently, they were asked to prepare a document for publication. One student working on an independent project made a thorough study of effects of biodegradable detergents on fish and other organisms. This brought widespread response from many companies and governmental offices. The value of these student-oriented activities is obvious when you are seeking support from school administrators.

4. Quincy High School in Quincy, Mass.

   Innovating relevant curricula into the school system takes time, effort, and special study. However,at this public high school, teachers and students worked together to design an anthropology course which would include physical anthropology for half the course. Later a course on Environmental Studies was developed which was presented by the Social Science Department and the Science Department employing a team approach to the teaching.

5. Douglas High School, Baltimore, Md.

   When some opposition to the implementation of an environment program in this school appeared, the City Science Supervisor was invited to see the students at work on their selected projects. This approach has strong persuasive power in convincing school officials.

   A student-authored booklet, "A Study of the Gwynns Falls Stream" was distributed to interested area teachers and school administrators.

VI. Limitations

1. Perhaps the greatest obstacle to be encountered in attempting to implement an environmental studies program is that of scheduling. Many schools are so regimented that it may be difficult for students and teachers to find the time needed for these activities. Since such a diversity of specific problems may arise here, it would be beyond the scope of this document to attempt a solution to all of them.

2. It may be possible to offer "time-trades" with other teachers. They may, for example, be much more willing to give up some of their lab or classtime in exchange for some of yours. It may be possible to convince athletic departments that an outside activity such as an all-school cleanup may be a worthy substitute for gym classes one day. Such tactics as these are only beginnings, but as enthusiasm grows among the students, faculty, and administration the possibilities are endless until finally the whole school may choose to revolve around an environmental theme.

3. One must also consider the possibility of alienating the local industrial polluters. This can be avoided by taking a positive rather than a negative approach to the pollution problem. It is better to ask, "How can _we_ work together to alleviate the problem?" If tact is used, you may find that industry is as interested as you are in working toward a solution and may even contribute in helping solve problems. A strong word of caution might be given to those who are impulsive and impatient in their dealing with the public at large.

"Resolving in essence the quest of human survival and the quality of human life on a planet of fragile hospitality - this is an issue which must become of immediate concern to all segments of society." _Ecotactics_, Part VII.

VII. Bibliography and Resources

Abelson, H. I., _Persuasion_, Springer Publishing Co., New York City, 1959.

Hall, D. M., _Dynamics of Group Action_, The Interstate Printers & Publishers, Inc., Danville, Ill., 1964.

Hillcourt, William, _Field Book of Nature Activities and Conservation_, G. F. Putnam's Sons, New York City, 1961.

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Hovland, C. I., A. A. Lumsdaine, and F. D. Sheffield, *Experiments on Mass Communications*, Princeton University Press, 1949.

Mann, John, *Changing Human Behavior* (Chapter 8, "Attitude Change Produced by Interpersonal Influence"), Charles Scribner's Sons, New York City, 1965.

Mitchell, John C., and C. L. Stallings (eds.), *Sierra Club Handbook for Environment Activists: Ecotactics*, Pocket Books, New York City, 1965.

Phillips, Edwin A., *Field Ecology*, D. C. Heath & Co., Boston, 1965. This is a BSCS Lab Block for high school students.

The Hampshire Environmental Information Center (HEIC) in cooperation with the Coalition for Environmental Quality (CEQ), University of Massachusetts, Amherst, Mass. This Center is intended to provide the Northeast area with one centralized point for the collection and dissemination of information related to environmental matters.

J. Moviemaking

I. Introduction

Movies are an innovative, motivational teaching technique which stimulate student interest, learning, and creativity. A movie project provides students with the opportunity to interact with peers and teachers to develop skills in the various areas involved in this type of activity and to increase understanding of the subject being covered. With adequate planning a moviemaking project can be introduced at any level, elementary through college. The complexity of the project depends on the age group involved.

II. Questions

1. Elementary level - The moviemaking project should be an integral part of a specified unit of study designed to make it more meaningful to the students.

   a. How would you like to make a movie about ______?

   b. What are some of the things we might have in our movie?

   c. What are some things our movie should tell people?

   d. What are some of the jobs we must do to make the movie?

   It might be feasible at this time to discuss the specific area or areas the film should include and a format of possible scenes.

2. High school level - The questions and discussions will be at a higher level of complexity.

   a. What is the aim of the movie?

   b. What effect is the movie trying to create?

   c. What message is to be made by the film?

   d. What equipment will be needed for the project?

   e. What time limitations are involved?

   f. Should we film all the facts on the subject being covered?

   g. Who is going to do the filming?

The moviemaking project at this level provides an excellent opportunity for teamwork, because the students can become involved in the more refined areas of this type of activity.

III. Equipment

1. Movie camera
2. Film
3. Light meter
4. Tripod
5. Editing equipment
6. Projector and screen
7. Lighting equipment
8. Notebooks

IV. Procedure

1. Decide on suitable areas for filmmaking activities.
2. Plan an itinerary that will provide as much sequence as possible.
3. Break students into teams to work on various aspects of the movie. Students should be working in their interest area. Teams might be assigned to:
    a. Care and cleaning of equipment.
    b. Arrange for lighting.
    c. Arrange for filming on private land (good public relations experience).
    d. Do the filming.
    e. Arrange for or do film development.
    f. Edit the film.

V. Previous Studies

Several groups in the Water Pollution Program (WPP) at Tilton School were successful in making suitable movies on water pollution. These can be obtained by contacting the program coordinator. The paragraph below was written after 2 days of filming. A list of scenes filmed also appears.

"The purpose of this movie is to follow a river from its headwaters to the Atlantic Ocean, showing the effects of human activites on the river. As we started to do this, we noticed we could divide the river into three parts. The first part is at the headwaters of the Fowler River which flows from Mt. Cardigan to Newfound Lake. In this section there are no human activities to affect the river. At Newfound Lake, the first influences of human activities are noticed as the lake is widely used for recreation. At this point the second phase of the movie starts. The outlet of Newfound Lake runs into the Pemigewaset River a few miles downstream. The Pemigewaset, polluted at this point, runs through Bristol to Franklin, where it meets the Winnipesaukee River and becomes the Merrimack River. The second phase ends up with the Merrimack flowing to Concord. Along this phase we see the introduction of human activities which will later increase. The third phase follows the Merrimack from Concord through all the towns along the river, until it empties into the Atlantic Ocean. Along this part of the river we observe the effects of heavy human activity upon the river. To give a better picture of what we wish to portray, we will be using one movie and two slide projectors running at timed intervals with the movie projector.

"Slides: the slides will be taken to show the area where the scene was shot. They will be used as a transition element, pulling some of the scenes together.

"Scenes That Have Been Shot

Scene 1. Sunrise on Mt. Cardigan. Shot at two frames per second. The first 30 seconds will be seen without slides as the sun jumps up.	Time: 90 seconds
Scene 2. Water dripping from a rock. This shows the water as it first seeps down the rocks.	Time: 45 seconds
Scene 3. Water pool. Shot from just below scene 2.	Time: 15 seconds
Scene 4. Moss and Stream. The stream joins with another.	Time: 26 seconds
Scene 5. Water bugs in pool. Used zoom to capture bugs.	Time: 20 seconds
Scene 6. Waterfall	Time: 20 seconds

Scene 7. Bullfrog and bubbles.
Just below falls. Time: 15 seconds

Scene 8. Welton Falls trail.
First shot on the Fowler River.
This stream is much larger than
those in the previous scenes. The
slides will serve as a transition. Time: 15 seconds

Scene 9. Small waterfalls along Fowler. Time: 25 seconds

Scene 10. From bridge to Fowler.
As in scene 8 there is a great jump
in the size of the stream. So
slides will be used as a transition. Time: 15 seconds

Scene 11. From lichen to suds.
Focus through lichen to suds. Time: 11 seconds

Scene 12. Spider web Time: 20 seconds

"The scenes listed above were shot for part 1. Those that follow are for part 3.

Scene 1. Pan bridge to boats off pier.
Newburyport. Time: 20 seconds

Scene 2. Boats in bay off pier.
Newburyport. Time: 15 seconds

Scene 3. Shooting toward Plum Island.
Newburyport. Time: 15 seconds

Scene 4. Below Rt. 495 bridge of river
and trees at Haverhill. Time: 15 seconds

Scene 5. At Lawrence, looking upstream
from bridge on south side. Time: 15 seconds

Scene 6. At Lawrence, effluent and
steam pipes taken from bridge. Time: 15 seconds

Scene 7. At Lawrence, effluent pipe
taken from bridge. Time: 15 seconds

Scene 8. Looking upstream from bridge
on the north side. Time: 15 seconds

Scene 9. At Lawrence, looking downstream from bridge on north side. Time: 15 seconds

"In a communications class, some juniors in high school made movies as a substitute for term papers. In a high school science class, students made a documentary movie on pollution and the environment.

"We have found in our experiences that one must focus on a scene for at least 12 seconds, as it takes a viewer that long to comprehend and enjoy the scene."

VI. Limitations

In some schools the cost of the equipment may be prohibitive. Thorough investigation of various sources indicates that some companies are quite willing to donate necessary equipment. The local camera store might be a possible source.

Students using the equipment should be carefully versed in its operation.

VII. Bibliography

Hughes, Robert, Film Book I, the Audience and the Filmmaker, Grove Press, Inc., New York City, 1959. This is a book for both teacher and student. It is "concerned with the situation of the serious filmmaker - how he works and what he is up against." The chapter which presents an interview with Fellini is most exciting.

Monier, P., The Complete Techniques of Making a Film, Amphoto, New York City, 1960. This is a book for the individual who has never picked up a camera before. It can be as a reference by junior high school students and older.

Peters, J. L. M., Teaching and the Film, International Documents Service, UNESCO, New York City, 1966. This book on the techniques of filmmaking can be used by the high school student.

K. Making Film Loops

I. Introduction

The film loop is a good way to stimulate interest and discussion on any topic; loops are 5 minutes long. If the student participates in the making of one of these on the water pollution problem. he is able to transmit his feelings to others by another communication media.

II. Questions

1. To lead into the activity ask students:
    a. Are the movies and other audiovisual aids that we have representative of this locality?
    b. What do you think would make a better presentation?
    c. Where do you think we should go to make a film loop?
2. To initiate activity ask students:
    a. Who would like to try to make a film loop?
    b. What do you think will make this an effective film loop?
3. To continue the activity ask students:
    a. How could this benefit other persons in our community?
    b. What can we do to make this available to other people?
4. To evaluate the students'performance consider such questions as:
    a. Did everyone contribute to this activity?
    b. Is the loop representative of the community's pollution problem?
    c. Is this loop representative of the pupils' concept of the pollution problem?

III. Equipment

1. Super 8mm or 8 mm movie camera
2. Film

3. Light Meter
4. Tripod
5. Editing equipment
6. Film loop projector and screen
7. Flood lights (if necessary)

Some companies will donate equipment or money to schools that are planning to have the students make movies.

IV. Procedure

1. Make a survey of your community to find suitable areas.
2. Plan an itinerary that will provide as much sequence as possible.
3. Make a definite plan and format for taking the film footage.
4. Edit your film.
5. Have a loop made of the edited film (send it out for loading).
6. Add sound track if desired.

V. Previous Studies

At Germantown Academy Biology 1 and 2 students did loops to demonstrate standard methods in biology laboratory techniques. These loops are now used by the students to prepare for lab.

VI. Limitations

1. Photographic equipment of good quality should be available.
2. The cost of needed materials may be prohibitive for some situations.
3. Individuals undertaking this project should have an adequate knowledge of the problem areas in the community.
4. There should be a thorough understanding of the limitations of camera that is to be used for this project.

VII. Bibliography

Hughes, Robert, Film Book I, the Audience and the Filmmaker, Grove Press, Inc., New York City, 1959. This is a book for both teacher and student. It is "concerned with the situation of the serious filmmaker - how he works and what he is up against." The chapter which presents an interview with Fellini is most exciting.

Monier, P., The Complete Techniques of Making a Film, Amphoto, New York City, 1960. This is a book written for the individual who has never picked up a camera before. This book can be used by junior high school students and older.

Peters, J. L. M., Teaching and the Film, International Documents Service, UNESCO, New York City, 1966. This is a book on the techniques of film making, which can be used by high school students.

L. Nonreturnable Containers

I. Introduction

This activity allows students to identify and react effectively to the problem of nonbiodegradable containers. Basic questions are provided; however, it is projected that questions will be posed by students that will require considerable class discussion. This activity may be carried out by junior and senior high students.

II. Questions

1. To lead to the activity ask:
    a. What varieties of nonreturnable containers are produced?
    b. What disposal methods are used by private and public communities?
    c. Does disposal present a problem? (If so, specify.)
2. Initiate the activity by asking:
    a. How can our concern for this problem be channeled?
    b. Is an advertising campaign the method to follow?
    c. Can our aid help mitigate the problem?
3. Continue the activity with:
    a. What public agencies and companies should be contacted for information?
    b. Is it plausible to appeal to the public through small projects under the auspices of various organizations such as the school?
    c. In what manner can the greatest success be achieved?
4. Evaluate the students by considering:
    a. Is success for this type of project possible on a large scale?
    b. Has personal involvement increased?
    c. Has community concern and cooperation increased at all?

III. Equipment

1. Trash cans filled with various types of nonreturnable containers
2. Photos of dumps or other areas used for the deposit of these containers
3. Maps and data for recording survey

IV. Procedure

1. Large group opening of class-teacher will utilize the discussion from Part II and/or provide articles for the students to read and evaluate in small groups and report on to the large group. (Articles identifying the problem posed with nonbiodegradeable containers.)
2. The teacher will invite the students to form their own group to evaluate the problem of nonbiodegradeables in their community. Areas for investigation might include: pathways for container wastes; compilation of material examples of nonbiodegradeables (NBD); companies that make, sell, and service NBD containers for our community; and an overview on the recycling of NBD materials.
3. Small group activity to plan approaches to the various offenders in order to communicate directly with them and discuss from the standpoint of either recycling or non-production ways to correct the problem.

V. Past Studies

A group of students at Germantown Academy became aware of the possibilities of recycling and started a chain letter to others urging a boycott of nonreturnable beverage containers. They also prepared a model legislative package for use on a state level.

VI. Limitations

1. The students must be encouraged continually to make their investigations seriously, particularly when approaching businessmen and manufacturers.
2. It is important for the student to value what he is investigating. The investigation should be of the student's own volition, and the teacher must allow for individual differences in approach to the issue.

3. The students must not be led into thinking change will occur overnight; however, they should, on the other hand be encouraged to be persistent in their efforts and thorough in their followup.

VII. Bibliography

Periodicals nowadays feature nonbiodegradeables frequently. If a file is begun on the subject by clipping newspapers and weekly news journals, a supply of information will develop quite quickly.

M. Anti-pollution Art

I. Introduction

This activity gives students a chance to express their personal attitudes towards pollution through creative art forms. Students will become more aware of the environmental crisis, and through their art, pass this awareness on to others. This activity can be used with any age group and requires no background or artistic ability.

II. Questions

1. To lead into the activity ask some questions similar to the following:
    - a. How can we communicate our concern about the pollution problem to others?
    - b. Could posters, collages, and other art forms be useful in communicating this concern?
2. To actually start the activity ask:
    - a. What materials could be used in making this art?
    - b. Should we run an antipollution art contest?
3. To continue the activity, ask questions like:
    - a. Should we use slogans, humor, and cliches in our posters?
    - b. If we run a contest, who will be involved? Just the class, one grade, the entire school, the whole community?
    - c. Should there be a prize as an incentive for this contest?
4. To evaluate the students' efforts:
    - a. Who is doing the activity, and with how much interest and enthusiasm is he going about it?
    - b. How well has each student planned his project?
    - c. Are the participants working?

III. Equipment

1. Litter (have the students collect this themselves)
2. Glue
3. Magic markers
4. Poster paper
5. Paints and brushes (Note: if posters are to be displayed outdoors, be sure to use weatherproof paint.)
6. Lots of enthusiasm and imagination

IV. Procedure

1. Be enthusiastic and interested about this project and your students will be too. Start off by taking your class to the scene of actual pollution: a nearby river, pond, beach, etc.
2. Have them observe the pollution and react to it, then start collecting the trash, some of which may be used in the actual making of their art projects.
3. Plan the project and collect any additional materials to be used in individual projects.
4. Begin to create an expression of your attitudes about pollution, using unique materials and ideas.

V. Previous Studies

1. One school recently held an environmental art contest for Earth Day (1970) in which not only posters and collages were entered, but also an assortment of oddities ranging from mobiles to a piece of artwork made using an old toilet. The contest was judged by certain faculty and student members of the environmental pollution class at the school, and prizes consisted of humorous, yet anti-pollution type gifts, such as waste paper baskets and fly swatters (instead of DDT).
2. The team from Beta Group, Tilton School in New Hampshire, decided that the items of metal trash were heavy enough to require welding. "Some of the collection we had to work with resembled parts of animals and plants to us. Pieces were spread out on the floor and arranged and rearranged by trial and error. We adopted the theme that pollution

is killing our natural flora and fauna, so in the future man might only be able to enjoy synthetic plants and animals made from these pollutants.

"We produced a crane or heron-type bird, a cattail, a turtle, and a skull, and crossbones. We made a sign by bending wire to form the words: pollution era-flora and fauna. These we stapled to a plank with a tacker stapler and balanced the sign on another item from the collection."

VI. Limitations

1. Few posters will be produced if students are not enthusiastic or if the activity is not publicized enough.
2. Posters placed outdoors become weather-beaten, colors may run.
3. If a contest is held, it could last too long.
4. Students should be allowed ample time to plan and work on their projects.
5. A contest with prizes would probably be more suitable for younger students (up through junior high) than for high school and up.
6. Heavy metal items may require welding, but are worth examining for other methods of joining. Welding could be done in the school maintenance shop, the vocational education shop or any privately-owned shop where the operator can be interested in helping the group with the project.
7. Cast iron pieces are difficult and costly to weld to steel pieces.

VII. Bibliography

Lynch, John, How to Make Collages, Viking Press, New York City, 1961.

Rottger, Ernst, Creative Paper Design, Reinhold Book Corp., New York City, 1968.

Schwartz, Therese, Plastic Sculpture and Collage, Hearthside Press, Great Neck, N. Y., 1969.

Seyd, Mary, Designing with String, Watson-Guptill, Inc., New York City, 1967.

N. Modelmaking

I. Introduction

This activity interests the students in making models of buildings, plants, and equipment. In this project, for all grades, it is intended that the students will do research on models thus learning about the control of pollution.

II. Questions

1. Lead to the activity by asking: what buildings or equipment can be found that help control pollution?
2. Initiate the activity with:
    a. How could you build a model of this kind?
    b. What materials could you use to make this?
    c. Would you make an actual working model or a cardboard one?
3. Continue the activity with:
    a. How would you make it work if you make a working model?
    b. What would a model like this show people who do not know about sewage plants, buildings, and equipment?
4. To evaluate students, ask:
    a. Is the model well constructed for the time allotted?
    b. If it is a working model, does it work correctly?
    c. Does the student know how it works; could he explain the process?
    d. Does the student feel he has gained an understanding of why we have such plants?

III. Equipment

1. Working model
    a. Cement mixture
    b. Sand, rocks, etc.

    c. Motor to run mixing device
    d. Aeration device
    e. Settling tank
    f. Glass tubing
    g. Glue (waterproof)
    h. Paint
    i. Labels

2. Nonworking model
    a. Cardboard and boxes
    b. Paint
    c. Glue
    d. Glass tubing
    e. Wood splints
    f. Pins
    g. Settling basin (small washing basin)
    h. Sand and gravel
    i. Labels

IV. Procedure

1. Make or get a blueprint of your idea.
2. Do research as to how it works and material needed for construction.
3. Construct the model.
4. Paint parts as necessary.
5. Label parts.

V. Previous Studies

Models often serve as the best illustration of things too large to see all at once. At Germantown Academy, two topographical maps (approximately 32 x 8 feet each) are under construction to show the entire Wissahickon Valley watershed and the school campus. When completed, the model will be mounted on the side walls of the science lecture hall. Several overlays will be used to illustrate biological, bacteriological, chemical, social, and political aspects of the watershed.

VI. Limitations

1. Materials may be hard to work with.
2. Glue may be hard to work with (watery, not flowing, etc.).
3. Time may be too short.
4. Small models take a long time to filter materials, thus patience is needed.
5. Projects may leak.

VII. Bibliography

"Aquarius . . . New Concept in Water Treatment," Neptune Micro Floc, Inc., Neptune Meter Co., Oregon.

Goodman, Brian, Package Plant Criteria Development, National Sanitation Foundation, Michigan, 1966.

Municipal Sewage Treatment Processes, U. S. Department of Health, Education, and Welfare, Washington, D. C.

Sewer and Sewage Treatment Plant Construction Cost Index, FWPCA Division of Construction Grants, Washington, D. C.

O. Student Planning of a Pollution Assembly

I. Introduction

This activity is designed to motivate students to plan a slide show on their local pollution problems to be shown at a school assembly. Such an assembly might act as a springboard to further activities on a larger scale if it is successful in bringing an awareness of local conditions to the student body. An assembly of this kind can be planned and produced by students at any level. Since it is possible to classify pollution into four categories: air, water, sight, and sound. With minor variations, this activity could be done with a tape recorder concentrating on sound pollution.

II. Questions

1. Lead to the activity by asking:
   a. Is the student body as a whole aware of our local pollution problems?
   b. What might we do to make them aware?
   c. Does merely telling them about pollution have as great an effect as showing it to them?
   d. Would a slide show, illustrating pollution in our city, town, be interesting to the students?
2. Questions which initiate the activity:
   a. Which sights in our area are particularly offensive?
   b. What pictures would really have an effect on the students in our school?
   c. Have any areas become polluted recently so that they might remember them as they were before?
   d. Are there any areas of potential natural beauty which have been spoiled by pollution?
3. Questions which continue the activity:
   a. Should we focus it on one site, showing it from many angles, times of the day, etc., or should we expand to cover many sights in the area?

b. Are there rivers that become more polluted as you pioneered downstream so that you could show a progression from beauty to pollution?

c. Should we have a sound track to accompany the slides?

d. Should we break up into groups in order to produce the show (i.e., editors, directors, photographers, sound coordinators, projection men, tape or record technicians, etc.)?

4. Questions which help the teacher evaluate the students' efforts:

a. Does the student try to produce a show which will have an effect on others or is he merely doing what he thinks is interesting? (Of course, he could be doing both successfully.)

b. How did the students and teachers in the audience react?

c. Did any long-term projects result from the assembly?

d. Were these or other students motivated to become involved in further assembly programs in the school?

III. Equipment

1. Cameras

2. Projector and screen

3. Tape recorder or record player (if a sound track will accompany slides)

IV. Procedure

1. The organization should be accomplished in the classroom. The activity can be accomplished in two ways depending on your circumstances. A class field trip approach may be utilized to take the pictures or students may be organized to take the pictures on their own time after school.

2. The students should agree on the total impact they wish to create on the audience and conscientiously strive for it. Most of this will occur during editing and arranging of the slides and coordinating of sound.

3. Sufficient time must be allowed for the slides to be developed and returned.

4. A date must be arranged for the assembly so that the students have a goal and real purpose to work towards.

5. After slides are obtained, the real work begins. They must be arranged and edited to create the desired effect. It may sometimes even be necessary to cut out good slides if there is an overabundance; one or two slides of certain scenes are sometimes more shocking than a dozen. The level of sophistication in coordinating sound and slides will vary according to available equipment and the students' talents; however, they should be aware that the two do interact with each other and if used carefully can become a real asset to the production.

6. There may or may not be any introduction or narration, depending again on the total effect desired by the students.

V. Past Studies

Young people seem to enjoy nothing more than working with cameras these days and the results of their efforts are often surprising. A group of students at Tilton School produced a film and slide show titled "The River" which they eventually showed to the participants of the water pollution program and which they plan to enter in an amateur film contest.

These students took about a week to complete filming. They began with a spring at the top of Cardigan Mountain in New Hampshire and followed the path it took to reach the Atlantic Ocean. The beginning slides included beautiful pastoral scenes, but these soon gave way to scenes of extreme pollution. As the spring became a stream and the stream a river, it passed the Franconia Paper Mill, which in 1954 contributed 96% of the pollution in the Pemigewasset River. Moving through Franklin, N. H., the Pemigewasset becomes the Merrimack River, and the students continued taking scenes of pollution in Concord, Manchester, and on into Massachusetts. After the picture taking was finished and the slides had been returned, we edited and added sound with a tape recorder. (Later this became a multi-media show and the students added a motion picture film in the center, showing their slides on both sides of it.)

VI. Limitations

Most schools have slide projectors as well as tape recorders or record players. Many suitable cameras are available or, if not, either the teacher, the students, or their parents can usually make one or several available for use. The class may decide to share the cost of having the slides developed or the school may have money available for this purpose. If none of the above is true, try asking the local camera store to lend you a camera and necessary equipment. In short, equipment is not a limitation. However, some problems may be encountered in travel if the sites chosen are not within walking distance. The problems here depend on the size of the class of the group actually doing the photography. Car pools might be organized among the parents and the group can be broken down into smaller units. Perhaps each unit could be in charge of photographing only one site thus reducing the total number who must visit each site.

VII. Bibliography and Resources

Blaker, Alfred A., Photography for Scientific Publication, W. H. Freeman and Co., San Francisco, Calif., 1965. This is especially good for techniques on small objects, insects, etc.

Boucher, Paul Edward, The Fundamentals of Photography, (3rd ed.), Van Nostrand Publishers, New York City, 1955. This is a good book for the fundamentals of working a camera and is also available in 4th edition, 1963.

There are many good books on the fundamentals of photography - your selection need only take into account the level of sophistication of your equipment.

P. Role Playing

I. Introduction

This activity is designed to familiarize students of 7th grade level and up with the function of local government and how they can take part in a town's decision making process. The setting is the local Town Hall where a special meeting has been called to consider the proposal that motor boating be banned on a nearby lake.

II. Questions

1. To lead into the activity, ask:

   What type of people would you expect to find present at a local town meeting on this issue?

2. To initiate and continue the activity, ask:

   a. Why would these people act and think as they do?

   b. Where could you find information on each character role?

   c. Which character would you like to be (followed by character assignments)?

3. To continue the activity, ask the students:

   Why they are playing the roles the way they are?

4. To evaluate the activity, ask the students to write a reaction paper. Note whether they really understand what was going on. Recapitulate the activity with the students to assure that they followed the development.

   If a tape recording has been made, this will be helpful. If more than one class has been recorded, play the tapes so that the classes may compare their activities.

III. Equipment

A tape recorder

IV. Procedure

1. Students are asked to imagine what various special interest actions could be expected to be in attendance at the town meeting and what statistics and facts these people might use to support their position.

2. Students are encouraged to identify with one of these factions by imagining themselves in this role for a few days prior to the actual meeting. See past studies in Section V.

3. Follow these tips on parliamentary procedure:

    a. Always wait until the moderator has recognized you before you begin to take the floor.

    b. Always stand when speaking.

    c. Always be courteous as you present your argument. Do not state opinions without being able to draw examples and give proof. Be accurate about dates and statistics.

    d. Do not ask a question directly to or speak to other members in the audience - always put such matters through the Chair.

    e. If you propose an amendment to the article in question, do not forget that the amendment must be prepared as a motion, seconded and then voted upon separately before going to the original question for ratification.

    f. Address the moderator as Mr. Chairman or Mr. Moderator.

    g. If there are many people trying to be recognized at the same time, you must stand and wait until you have an opportunity to speak.

    h. You may through the Chair ask for an opinion from any of the local town officials (i. e., town counsel, local board of health official, local planning board official, town engineer).

V. Past Studies

Procedures outlined in Section IV were carried out. Discussion of the motor boating ban article was lively and enjoyable and lasted for an hour and 15 minutes. Suggested characters which were used in this particular role play were:

1. Chamber of Commerce president or member: enthusiastic about the possibilities for making money on tourist trade in the area. Feels that preventing people from using powered craft at the lake will cause people who plan to develop property around this region into motels, ice cream stands, hamburger stands, and other franchises to lose the money they invested.

2. Members of a rapidly organized group who call themselves "The Lake Boat Owners and Water Skiers Federation" (sports loving, "Pepsi-generation" types).

3. Local members of real estate and brokerage firms feel that both they and people from cities would be discriminated against.

4. A representative from your school (pick your own character).

5. A private lot and boat owner who has recently received permission through the planning board to build a cottage on the lake. He feels that such a ruling would be unfair to him since he assumed that when he invested the majority of his life savings in this recreational area that there would be no restrictions on his recreational activities.

6. An old resident who is basically fed up with newcomers intruding more and more into what had been to him an area of peace and tranquility for as long as he can remember.

7. A poorly-motivated individual who is a rather shady character and has a personal financial interest in selling a product which he claims will eliminate oil scum.

8. Local representative of the John Birch Society who sees this bill as another example of unnecessary social control which is detrimental to the American traditional concept of personal freedom.

9. Representative of local Conservation Committee who wishes to preserve the natural beauty and environmental quality of the area.

10. Moderator of the town meeting.

Participants found useful in their role participation, the brief guide to parliamentary procedure which is included in the procedure section.

VI. Limitations

1. Students may have no experience in role playing or parliamentary discussion. It may be useful to spend 10 minutes in a dry run dealing with the suggested issue.

2. A student with a rather forceful personality is needed as the moderator.

3. Students must have the time to obtain a thorough knowledge of their role and how it relates to the issue in order to guarantee enthusiastic participation.

VII. Bibliography

If possible, select games the students are familiar with and use the rule books as a basis of discussion.

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